Summary Report – Implementation and Completion of Groundwater Characterization Work Plan

United States Steel Corporation – Clairton Works
Clairton, Pennsylvania

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List of Acronyms & Abbreviations

AST	aboveground storage tank
ASTM	ASTM International
bgs	below ground surface
btoc	below top of casing
BTX	benzene, toluene, and xylene
CB&I	CB&I Government Solutions, Inc.
cm/s	centimeters per second
COA	Consent Order and Agreement
CP	Competent Person
CYMW	Crane Yard monitoring well
ft^2/day	square foot per day
GCWP	Groundwater Characterization Work Plan
gpd	gallons per day
KER	Keystone Environmental Resources, Inc.
Koppers	Koppers Industries, Inc.
Kucera	Kucera International, Inc.
LNAPL	light non-aqueous phase liquid
mg/L	milligrams per liter
MRTW	Motor Shop Repair Area temporary well
MSC	medium-specific concentration
msl	mean sea level
MW	monitoring well
NAPL	non-aqueous phase liquid
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity units
OW	observation well
P.L.	Public Law
PADEP	Pennsylvania Department of Environmental Protection
PID	photoionization detector
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
RW	recovery well
SHS	statewide health standard
SR 837	Pennsylvania State Route 837
THG	THG Geophysics, Ltd.
TTI	Terra Testing, Inc.
TW	temporary well
U. S. Steel	United States Steel Corporation
USEPA	U.S. Environmental Protection Agency
WDNR	Wisconsin Department of Natural Resources
WEG	Weavertown Environmental Group

1.0 Introduction

CB&I Government Solutions, Inc. (CB&I) has prepared this Summary Report – Implementation and Completion of Groundwater Characterization Work Plan for United States Steel Corporation (U. S. Steel) to conform with the recommendations of the Groundwater Characterization Work Plan (GCWP) that was approved on December 13, 2013 as part of the requirements of the Corrective Actions Section of a March 15, 2013 Consent Order and Agreement (COA) among U. S. Steel; Koppers Industries, Inc. (Koppers); and the Pennsylvania Department of Environmental Protection (PADEP) regarding activities being conducted at the U. S. Steel Mon Valley Works Clairton Plant located at 400 State Street, Clairton, Allegheny County, Pennsylvania (site) (Appendix A). A site location map is provided as Figure 1. Specifically, Paragraph 6 of the 2013 COA Corrective Actions Section requires that within 60 days from the date of the approval of the GCWP, U. S. Steel is required to begin implementation of the GCWP, to be followed by the submittal to PADEP of a Groundwater Site Characterization Report based on the schedule contained within the approved GCWP.

To assist in compliance with the requirements of the 2013 COA, U. S. Steel contracted CB&I to complete the 120-Day Compliance Summary Report and the 180-Day GCWP, as required in Paragraphs 4 and 5 of the COA.

The 120-Day Compliance Summary Report (CB&I, 2013a) was completed and submitted to the PADEP compliance specialist on July 12, 2013. That document included a summary of the following activities:

- A review of existing U. S. Steel files
- Evaluation and gauging of site monitoring wells
- Surveying and aerial photography
- Production of a site topographic map
- Preparation of a description of groundwater collection methods currently in use
- Providing a concise description of the Early Warning System used at the site

Subsequently, the 180-Day GCWP (CB&I, 2013b) was completed and submitted to the PADEP compliance specialist on September 23, 2013. That document included the following recommendations:

- Expansion of the groundwater monitoring and sampling protocol to provide more complete delineation of shallow and deep groundwater plumes

- Repair and maintenance of existing wells

- Installation of four additional monitoring wells to assist in delineation of the shallow and deep groundwater plumes
- Plugging and abandonment of unused or otherwise nonfunctional wells
- An assessment of free product recoverability
- An assessment of the effectiveness of ongoing groundwater recovery efforts

The GCWP was approved by the PADEP without comment by letter dated December 13, 2013. CB&I was subsequently retained to complete the groundwater characterization activities described in the GCWP. As identified in Section 6.0 of the GCWP, within 90 days after the receipt of the fourth consecutive quarter of groundwater data obtained from the wells installed as part of the GCWP, a summary report will be submitted to PADEP that describes activities conducted and provides recommendations for additional testing and/or field work to fill data gaps needed to complete the site characterization and enable preparation of a complete groundwater site characterization report as specified in Paragraph 6 of the 2013 COA. This report summarizes activities conducted to implement the GCWP, discusses the findings of those activities, defines data gaps that remain, and recommends activities to address those data gaps.

The remainder of Section 1.0 of this summary report presents a description of the site and presents the regulatory framework, including references to specific sections of the 2013 COA as they pertain to the preparation of this report. Section 2.0 provides a description of the site geologic and hydrogeologic setting. Section 3.0 details the specific groundwater characterization activities conducted. A discussion of the results of those activities is provided in Section 4.0, followed by recommendations in Section 5.0. Finally, Section 6.0 presents a summary, and Section 7.0 lists the references used to generate this report.

1.1 Facility Information

The facility information provides a description of the facility location, the four main operational areas of the plant, 11 study areas as defined by past environmental investigations and plant operations, and the site groundwater well network. Each of these items is discussed in the following subsections.

1.1.1 Facility Location

The U. S. Steel Clairton Plant is located approximately 20 miles south of Pittsburgh on 392 acres along 3.3 miles of the west bank of the Monongahela River in Clairton, Allegheny County, Pennsylvania (Figure 1), with an additional 108-acre parcel located west of Pennsylvania State Route 837 (SR 837) near the midpoint of the 3.3-mile stretch along the river bank (Figure 2). The Clairton Plant is in an area zoned as primarily residential and commercial/industrial.

1.1.2 Operational Areas

The Clairton Plant is divided into four distinct operational areas. Each operational area contains one or more project study areas (Section 1.1.3). Three of the four operational areas of the Clairton Plant are located east of SR 837 and are divided as follows:

- The southern part of the property, identified as the "Steel Works Area" on Figure 2, is operationally inactive but contains a coke oven maintenance shop, emergency waste-water storage tanks (formerly used as anhydrous ammonia storage tanks), coke storage areas, Clairton Works Hospital, and several buildings not related to active operations.
- The central part of the property is the main manufacturing or "Keystone Area," which is subdivided into Unit No. 1 and Unit No. 2, from south to north. A portion of the northern third of the property is owned and operated by the Koppers Tarben Plant, which processes coal tar produced as a by-product of the coke-making processes at the Clairton Plant.
- The northern portion of the property (identified as the "Coal Storage Area" on Figure 2) is used as a coal storage yard and diesel fuel station for heavy equipment.

The fourth area of the Clairton Plant includes an additional parcel located west of SR 837 and the central operations area, identified as the "Peters Creek Coke Yard" on Figure 2. This strip of property containing approximately 108 acres is used for coke storage and is where the Peters Creek Lagoon was located.

1.1.3 Study Areas

As shown on Figure 2, the Clairton Plant is subdivided into 11 separate study areas based on plant operations that occur in each of these areas, as well as historic environmental investigations that have been completed in the past. For purposes of consistency in identifying these specific plant study areas, the area definitions used by U. S. Steel at the Clairton Plant have been retained. Each of the study areas is described below; more detailed descriptions were provided in the 2013 GCWP (CB&I, 2013b). Results of the 2014-2015 groundwater characterization activities (Section 4.0) and the recommendations stemming from them (Section 5.0) are reported by study area.

1.1.3.1 Coal Storage Area

The Coal Storage Area is located in the northernmost section of the Clairton Plant and is used primarily as a coal storage yard (Figure 2). In addition, a diesel fueling station and truck wash for heavy equipment are found in this area. The Coal Storage Area is located along an approximately one-half-mile stretch of the western bank of the Monongahela River and extends beneath the Clairton-Glassport Bridge. Within the Coal Storage Area north of the Clairton-Glassport Bridge, U. S. Steel maintains two coal pile settling basins. The southern portion of the

Coal Storage Area contains the plant transmission building and is also used for storage of miscellaneous plant parts and equipment.

1.1.3.2 BTX Plant Area

The BTX Plant Area is located adjacent to the southern extent of the Coal Storage Area (Figure 2). The former BTX Plant is where benzene, toluene, and xylene (BTX) were extracted from the by-product coal tar associated with coke production at the Clairton Plant and stored in aboveground storage tanks (ASTs). The BTX Plant Area currently includes plant offices leased by Koppers, the Light Oil Storage Area, the Utilities Division for the Clairton Plant, and the boiler houses. There are a number of buildings not related to active operations that are located in the BTX Plant Area as well as remnant structures associated with the former BTX Plant benzene AST containment. Peters Creek, which flows through culverts located beneath the ground surface of the Clairton Plant (Figure 2), discharges to the Monongahela River in this area via an outfall.

1.1.3.3 Tar Plant Area

The Tar Plant Area is located southeast of the BTX Plant Area, northwest of the Second Unit Coking Area, and northeast of the Norfolk Southern Railroad (Figure 2). This area represents the location of the former U. S. Steel Tarben Plant, which is currently owned and operated by Koppers. The process involves the conversion of crude coal tars into liquid pitch and other liquid products such as creosote and chemical oil for commercial sale.

1.1.3.4 Oil Seep Investigation Area

The Oil Seep Investigation Area is located east-southeast of the BTX Plant Area, northeast of the Tar Plant Area, north of the Second Unit Coking Area, and northwest of the Keystone Area along the western river wall of the Monongahela River (Figure 2). This area was the focus of an environmental investigation that began on September 18, 1990, regarding an oil seep at the river wall resulting in a discharge to the Monongahela River. A recovery well system operates in this area (Section 5.4.1).

1.1.3.5 Keystone Area

The Keystone Area encompasses the largest area of the Clairton Plant and is located along the west bank of the Monongahela River, east-southeast of the Second Unit Coking Area, southeast of the Oil Seep Investigation Area, and northeast of the First Unit Coking Area (Figure 2). This is the main operations area of the plant containing No. 1, No. 2, and No. 5 Control Rooms; Contaminated Water Treatment Plant ("Bug Plant"); Aeration Basins; Keystone Cooling Tower; Tar Storage; Compressor Building; numerous batteries; tar decanters; the sulfur plant; and first and second unit coolers.

1.1.3.6 Second Unit Coking Area

The Second Unit Coking Area is located east-southeast of the Tar Plant and west of the Keystone Area adjacent to the Norfolk Southern railroad tracks directly east of Peters Creek Coke Yard and east of SR 837 (also known as State Street through that portion of Clairton) (Figure 2). This portion of the Clairton Plant contains the Clairton Plant main offices, numerous batteries, and other U. S. Steel facilities.

1.1.3.7 First Unit Coking Area

The First Unit Coking Area is located along the west bank of the Monongahela River, southeast of the Keystone Area (Figure 2). It represents the area in the southernmost extent of what are considered to be the active operations of the Clairton Plant. The First Unit Coking Area contains numerous batteries as well as the anhydrous ammonia ASTs, the Keystone Plant offices, and a variety of contractor and U. S. Steel facilities.

1.1.3.8 Steel Plant (Works) Area

The Steel Plant (Works) Area is the location of the former iron and steel production facilities of the early 1900s (Figure 2). This portion of the Clairton Plant currently houses numerous offices, coke storage operations, the Clairton Plant helipad, the Maple Avenue Gate, a coke oven maintenance shop, a U. S. Steel wildlife refuge, the Clairton Works Hospital, and several buildings not related to active operations.

1.1.3.9 Peters Creek Coke Yard Area

The Peters Creek Coke Yard Area of the Clairton Plant consists of approximately 108 acres of land containing the Coke Yard Storage Area and the former Peters Creek Lagoon southwest of SR 837 (Figure 2). The former Peters Creek Lagoon was a man-made impoundment which was utilized by U. S. Steel for disposal of materials generated from the coke-making operations that was subsequently closed. The lagoon contents consisted primarily of tar and similar substances with varying composition and viscosities. Closure activities for the Peters Creek Lagoon began in 1998 and were completed in 2003. These activities included installation of a slurry wall to prevent the contents of the lagoon from migrating into the groundwater and impacting Peters Creek, in-situ and ex-situ solidification of the contents of the lagoon to provide a stable foundation for the placement of an impervious cap, and construction and installation of the impervious cap. The Peters Creek Coke Yard is currently used as a sorting and storage area for different sizes of coke produced at the Clairton Plant.

1.1.3.10 Motor Repair Shop Area

The Motor Repair Shop Area, within the First Unit Coking Area, is located between the Maple Avenue Gate and the southwestern boundary of the First Unit Coking Area (Figure 2) and currently functions as a repair shop for plant operations motors. This area was the subject of a soil and groundwater investigation from 1994 to 1998 following the discovery of petroleum hydrocarbons and chlorinated hydrocarbons during a city water line repair.

1.1.3.11 Crane Yard Area

The Crane Yard is located along Maple Avenue, within the Steel Works Area south of the First Unit Coking Area, and southeast of the Motor Repair Shop (Figure 2). This area was the subject of a soil and groundwater investigation following the discovery of an underground storage tank leak in 1992. The Crane Yard is currently used as a repair shop for cranes and train engines.

1.1.4 Site Well Network

An existing system of wells, augmented by additional wells installed in 2014 (Section 3.1), are used to monitor groundwater conditions at the site and control the migration of impacted groundwater. The on-site well network includes designated monitoring wells (given the prefix "MW"), wells originally intended as temporary wells ("TW") but now used as monitoring wells, observation wells ("OW"), and groundwater recovery wells ("RW"). Monitoring wells in the Crane Yard Area carry the designation "CYMW" (as listed by U. S. Steel), whereas those in the Motor Shop Repair Area are designated "MRTW" (likewise). There is also a series of monitoring wells in the Peters Creek Coke Yard area carrying the "P-" prefix (e.g., P-14A). The locations of the facility wells are shown on Figure 2.

1.2 Regulatory Framework

The 2013 COA enables PADEP to act under its authority to administer and enforce The Clean Streams Law (Act of June 22, 1937, Public Law [P.L.] 1987, as amended, 35 P.S. §§691.1-691.1001 ["Clean Streams Law"]; Section 1917-A of the Administrative Code of 1929, Act of April 9, 1929, P.L. 177, as amended, 71 P.S. §510-17); and the rules and regulations promulgated thereunder.

The 2013 COA lists a series of findings that describe the overall project setting, identify the broad extent of groundwater impacts from historic plant operations to a public potable water supply, and discusses the unauthorized National Pollutant Discharge Elimination System (NPDES) discharges reported by U. S. Steel to PADEP. Further, the 2013 COA provides a list of corrective actions to be implemented by U. S. Steel and/or Koppers that will ultimately culminate in the development and approval of a Groundwater Monitoring and Control Work Plan for the Clairton Plant. As indicated above, a complete copy of the 2013 COA is presented in Appendix A.

In addition to fulfillment of the conditions and terms of the 2013 COA and referenced NPDES permit limits and Act 2 regulations, U. S. Steel is committed to fulfillment of U.S. Environmental Protection Agency (USEPA) guidelines and requirements, including those promulgated under the Resource Conservation and Recovery Act (RCRA).

2.0 Geologic and Hydrogeologic Setting and Conditions

This section presents an overview of the regional and local physical features that have an influence on the migration of surface water and/or groundwater from the facility. They include physiographic information, geomorphology, and geology/hydrogeology of the region. Figure 2 depicts the Clairton Plant topographically and shows the locations of the site-wide well network. Appendix B includes a series of geologic and hydrogeologic drawings including a cross section location map, geologic and hydrogeologic cross sections, and a site plan showing the top of bedrock contours depicting locations of features that could influence groundwater flow (Appendix B, Drawing B-3). The geologic drawings were generated based on well log data available for the Clairton Plant.

2.1 Physiography and Topography

The Clairton Plant is situated in the Pittsburgh Low Plateau section of the Appalachian Plateau physiographic province. The Pittsburgh Low Plateau is characterized by nearly flat-lying to gently folded Pennsylvanian-age sedimentary rock strata, which have been maturely dissected by stream erosion in a dendritic drainage pattern. The Clairton Plant is located on an alluvial floodplain, characterized by the lateral deposition of sediments by the Monongahela River. Various types of fill material have been placed on top of these alluvial sediments to raise the Clairton Plant to its current elevation.

The facility is located in the Ohio River Watershed. Peters Creek flows across and under the Clairton Plant and discharges to the Monongahela River at Peters Creek Outfall 081 along the Clairton Plant river wall (Figure 2). The Monongahela and Allegheny Rivers join downstream to form the Ohio River in Pittsburgh.

As shown on Cross Section A-A' (Appendix B), ground surface elevations in the immediate vicinity of the Clairton Plant range from approximately 760 feet above mean sea level (msl) in the plant operations area of the property (east of SR 837/State Street, closest to the Monongahela River) to approximately 790 feet msl at the Peters Creek Coke Yard (west of SR 837/State Street, Figure 1). The ground surface elevation at the Clairton Plant has been built up to an elevation approximately 40 feet higher than the pool elevation of the Monongahela River, with a river wall at which mooring and unloading of coal barges occurs. Historical mapping indicates that the topography of the Clairton Plant area prior to construction activities exemplified the typical topography of the region, with rolling hills dissected by tributary valleys and alluvial floodplains. Plant construction activities, including extensive grading, resulted in a leveled landscape with a gentle slope toward the northeast and east, followed by an abrupt vertical drop in elevation at the river wall. Peters Creek Coke Yard is higher in elevation due to buildup from the storage of slag and coke and from the creation and closure activities of the former Peters Creek Lagoon (Cross Section A-A').

2.2 General Geology and Hydrogeology

Boring logs have been prepared by various environmental consultants including The Chester Engineers; Keystone Environmental Resources, Inc. (KER); and Weavertown Environmental Group (WEG) during previous environmental investigations including, but are not limited to, the *Phenol and Cyanide Study, Well 7 Area Study Reports (Phases I and II),* and *Well 10 Area Study Reports (Phases I and II).* Those boring logs indicate that bedrock consists of silty shales and claystones. The bedrock lithologies identified on those boring logs correlate regionally with the Glenshaw Formation (Conemaugh Group) of Pennsylvanian age, which consists primarily of sandstone and shale/claystone units with thin, interbedded limestone and coal beds. The top of the Upper Freeport Coal is the base of the Glenshaw Formation and Conemaugh Group (Shultz, 1999).

The Clairton Plant is located on the northwest flank of the Roaring Run-Murrysville Anticline. This structure is a double-plunging anticline with a northwest-southeast trending axis. The plunge of the anticline in the vicinity of the Clairton Plant is toward the southeast. Rock formations at the facility dip gently away from the axis of the anticline to the northwest, but are also influenced by the southeastern plunge (Koppe, 1961).

The original ground surface, as described above, mimics the configuration of the top of bedrock. This tendency for the pre-construction topography to follow the top of bedrock surface, typical for the region, is important in understanding groundwater flow in the shallow groundwater-bearing zones beneath the facility. Although the original ground surface has been reconfigured by construction activities, the shallow groundwater flow surface is typically not influenced by those construction activities unless a groundwater control structure is included or the construction inhibits groundwater recharge. Shallow groundwater flows predominantly to the northeast, but the influence of the Peters Creek channel does create a limited area where shallow groundwater flows northwest toward Peters Creek for the portion of the property identified as Peters Creek Coke Yard (Figures 3A through 3C).

Regional structural controls include dip and plunge direction and the influences of fractures including shale partings, bedding plane fractures, joint patterns, and faults (although the latter are rare in the immediate area), which also influence regional groundwater flow. Overall, in western Pennsylvania, regional groundwater flow in rock occurs as a result of interconnected fracture systems and/or solution openings (Piper, 1933). These fracture systems can often be identified by the presence of surface lineaments and/or surface water drainages.

2.3 Site Hydrogeology

Site-wide groundwater elevation measurements were collected on multiple occasions. Those data collected in May 2013 include all located existing monitoring wells at the site. A summary of groundwater elevation measurements collected at the site during groundwater site characterization activities is provided in Table 1.

Based on the differences in lithology and groundwater surface elevations, and on the well log and well screen data provided by U. S. Steel, two groundwater-bearing zones have been identified at the facility, hereafter referred to as the "shallow groundwater zone" and the "deep groundwater zone." The two groundwater-bearing zones are described in more detail in Sections 2.3.1 and 2.3.2. The distinct difference between the groundwater potentiometric surfaces of the two zones can be seen on Cross Section B-B' (Appendix B). Depth-to-groundwater data were collected from 15 different pairs of clustered wells at the site during the May 2013 well evaluation process. A summary of the differences in the hydraulic head data within the individual well pairs is provided in the following table.

Table 2.3: Groundwater Elevation Differences in Nested Well Pairs

Study Area	Shallow Zone		Deep Zone		Head Difference (feet)
	Well ID	Groundwater Elevation (feet msl)	Well ID	Groundwater Elevation (feet msl)	
BTX Plant Area	TW-53	756.71	TW-52	741.22	15.49
BTX Plant Area	TW-72	730.17	TW-73	722.10	8.07
Keystone Area	TW-51	741.03	TW-50	721.46	19.57
Keystone Area	TW-57	740.42	TW-56	723.18	17.24
Keystone Area	TW-61	738.30	TW-60	721.82	16.48
Keystone Area	TW-74	740.73	TW-75	723.33	17.40
Keystone Area	TW-76	744.92	TW-77	737.17	7.75
Keystone Area	TW-80	739.53	TW-81	721.39	18.14
Keystone Area	TW-82	732.42	TW-83	721.70	10.72
Peters Creek Coke Yard	MW-103A	738.33	MW-103B	730.86	7.47
Peters Creek Coke Yard	P-1S	734.61	P-1D	728.47	6.14
Peters Creek Coke Yard	P-2S	751.17	P-2D	734.48	16.69
Peters Creek Coke Yard	P-3S	737.39	P-3D	730.52	6.87
Peters Creek Coke Yard	P-4S	738.01	P-4D	734.82	3.19
Peters Creek Coke Yard	P-8S	732.28	P-8D	729.09	3.19

Groundwater elevation contour maps for the shallow groundwater zone and the deep groundwater zone were prepared from the gauging and survey data collected during the implementation of the GCWP (July 2014 to January 2015) to assess groundwater flow beneath the Clairton Plant. These maps are presented as Figures 3 (A, B, C) and 4 (A, B, C), respectively. Groundwater elevations measured in U. S. Steel's regularly sampled wells as part of the 2013 COA and those included in the GCWP were not collected on the same date in April 2014. As a result, no potentiometric surface maps were generated for that quarter.

Beginning with CB&I's July 2014 groundwater sampling event, all wells sampled as part of the 2013 COA and GCWP were gauged for their groundwater elevations for comparative purposes and to provide a groundwater elevation data set for the generation of shallow and deep groundwater elevation contour maps. Groundwater conditions in wells screened through both the shallow and deep groundwater zones were determined to reflect the shallow groundwater elevation surface and are presented as such.

2.3.1 Shallow Groundwater Zone

The shallow groundwater zone lies within the fill (slag, coke, coal, gravel) and upper alluvial material (mixed sands, silts, and clays) at the Clairton Plant, as indicated on the available boring logs and depicted on the site geologic and hydrogeologic cross sections (Appendix B, Drawing B-2). Depth to groundwater measured during implementation of the GCWP within the shallow groundwater zone ranged from approximately 0.56 foot below ground surface (bgs) in TW-53, in the western part of the BTX Plant Area, to 43.65 feet bgs in MW-16, along the western boundary of the former Peters Creek Lagoon. None of the wells selected to be gauged and sampled during the GCWP were observed to be dry. During implementation of the GCWP, unrelated work was completed to investigate shallow groundwater influences to the basement of one of the buildings located in the BTX Plant Area. That investigation identified that the shallow groundwater zone occurs at or very near the ground surface in the BTX Plant Area and confirms the shallow depth to groundwater of 0.56 foot bgs in TW-53 (Figures 3A through 3C). Historical investigations site-wide indicate that the shallow groundwater zone being at or very near the ground surface only occurs in the BTX Plant Area.

Review of the "*Well 10 Area Study Phase II Report*" (KER, 1991a) indicates that three wells (TW-62, TW-63, and TW-64) completed as part of the Well 10 Study were installed within the shallow zone with the shallow groundwater zone occurring at 0.21 foot bgs (TW-62) and 3.42 feet bgs (TW-64). The location of these wells as provided in the historical documentation indicates that the occurrence of shallow groundwater at or very near the ground surface appears to be localized to the west-southwestern portion of the BTX Plant Area, near the light oil tank farm. Only Well TW-53 still exists at the Clairton Plant as the remaining three wells (TW-62, TW-63, and TW-64) were damaged and/or abandoned.

Based on depth-to-water measurements in site wells collected during 2014 and 2015, groundwater elevations within the shallow groundwater-bearing zone range from approximately 716 feet msl (MW-15) to 757 feet msl (TW-53) across the Clairton Plant. The water table is found within fill and upper alluvial sediments in this shallow zone. Figures 3A through 3C present groundwater elevation contour maps of groundwater elevations measured in wells completed in the shallow horizon. As shown on all three figures, shallow groundwater flow at the Clairton Plant is dominated by flow from the south and west to the north and east, with groundwater discharging to Peters Creek (which flows beneath the plant) and to the Monongahela River. Based on the difference in hydraulic head values between the shallow groundwater zone and the deep groundwater zone, as indicated in Table 2.3 above, there is also a vertical (downward) component of flow in all of the places where comparative data are available.

Local groundwater flow features generated by ongoing groundwater recovery efforts include a well-developed cone of depression around Recovery Well RW-38 in the Tar Plant Area. West of the RW-38 cone of depression is a localized area of increased groundwater elevation ("mounding") at or very near the surface in the southern part of the BTX Plant Area. Groundwater from this mounded area flows north-northeast toward the BTX Trench and Monongahela River.

At the Peters Creek Coke Yard, shallow groundwater generally flows from the south and east to the north and west and most likely discharges to Peters Creek. The former Peters Creek Lagoon (which was closed circa 1998, contained within an impermeable slurry wall, and capped) acts as an effective barrier to lateral groundwater flow, as shown by the groundwater elevation contour wrapping around the eastern or western portions of the slurry wall (Figures 3A to 3C).

2.3.2 Deep Groundwater Zone

The deeper of the two overburden groundwater zones lies within sand and gravel and silty clays overlying the bedrock at the Clairton Plant (Appendix B) and is hydraulically separated from the overlying mixed sediments by a layer of alluvial silty to fine sandy clay. Based on the results of hydraulic characterization tests (slug tests and pumping tests) conducted by The Chester Engineers (1981) and KER (1991), the clay layer at the Clairton Plant that separates the shallow and deep groundwater-bearing units has a hydraulic conductivity (K) value on the order of 10^{-5} centimeters per second (cm/s), as compared to 10^{-3} cm/s in the underlying gravels and sands, and 10^{-2} cm/s to 10^{-4} cm/s in the overlying fill and mixed alluvial sediments. As shown on the cross sections (Appendix B), this clay layer ranges in thickness from 3 feet (at TW-90 in the Tar Plant Area) to 38 feet (at TW-53, in the southeastern portion of the BTX Plant Area) and appears to be laterally continuous across the Clairton Plant, pinching out at the bank of the Monongahela River in the vicinity of RW-94 and MW-99 (Cross Section C-C', Appendix B).

Measured depths to groundwater within the deep zone from April 2014 through January 2015 ranged from approximately 14.68 feet bgs (TW-66) to 43.63 feet bgs (MW-103B). Calculated groundwater surface elevations range from approximately 722 feet msl (TW-58) to 747 feet msl (TW-66).

Figures 4A to 4C present groundwater elevation contour maps of groundwater elevations generated from the depth to water measured in wells completed in the deep groundwater zone. As shown on all three figures, deep groundwater flow at the Clairton Plant is dominated by flow from the south and west to the north and east with discharge into the Monongahela River. At the Peters Creek Coke Yard Area, deep groundwater flows from the south and east to the north and west with discharge to Peters Creek and toward the Clairton Plant.

3.0 Summary of Groundwater Characterization Activities

The GCWP identified a number of data gaps that were recommended to be filled including the following:

- Horizontal and vertical plume extent in the BTX Plant Area, Oil Seep Investigation Area, Keystone Area, and Peters Creek Coke Yard Area
- Free product volume and recoverability of select wells which exhibit quantifiable amounts of residual free product at the site
- Assessment of ongoing groundwater recovery and control efforts in the BTX Plant Area, Tar Plant Area, Oil Seep Investigation Area, Keystone Area, and Peters Creek Coke Yard and their effectiveness

Based upon those data gaps, a scope of work was developed as part of the GCWP. The remainder of this section discusses the implementation of the groundwater characterization recommended tasks.

Planning and preparation for field activities to implement the GCWP began on January 6, 2014 with the identification and selection of contractors. THG Geophysics, Ltd. (THG) of Murrysville, Pennsylvania, was selected to provide subsurface geophysical and utility location services. Terra Testing, Inc. (TTI) of Washington, Pennsylvania, was selected to provide drilling, well plugging and abandonment, and well repair services. In order to maintain consistency with previous sampling at the facility, Pace Analytical Services, Inc. of Greensburg, Pennsylvania, was chosen as the provider of laboratory analytical services. Kucera International, Inc. (Kucera) of Willoughby, Ohio, was selected to provide surveying services for newly installed and repaired monitoring wells.

3.1 Installation of Additional Monitoring Wells

To further assist in groundwater characterization and provide horizontal and vertical delineation of impacts to shallow and deep groundwater-bearing zones at the site, three new shallow wells and one new deep monitoring well were installed on site. U. S. Steel conducted a drilling safety line-up meeting with CB&I, and the proposed drilling locations were marked to allow plant utilities personnel adequate time to clear the proposed locations of subsurface utilities prior to subsurface activities commencing. A follow-up meeting was conducted on March 10, 2014, among U. S. Steel, CB&I, THG, and TTI to discuss the results of the plant utility clearance and health and safety concerns. During the March 10, 2014 meeting, utility services for the Clairton Plant informed CB&I that the location of proposed MRTW-11 would need to be moved to the northwest approximately 10 feet in order to avoid a combined sewer/storm water line and other subsurface utilities. U. S. Steel also informed CB&I that an Occupational Safety and Health

Administration-certified Excavation Competent Person (CP) would be needed to oversee drilling activities. Subsequent efforts involved the identification and retention of a CP for the well drilling activities.

3.1.1 Utilities Clearance

In addition to completing the PA One Call notification as required by law prior to commencing subsurface activities, THG utilized geophysical methods to locate potentially unmarked subsurface utility lines or other obstructions in the vicinity of the proposed new wells on March 31, 2014. As a result of these activities, the location for proposed Monitoring Well P-20 was moved approximately 13 feet south-southwest.

On April 9 and 10, 2014, following the tailgate health and safety meeting, review of the health and safety plan and work permit, and completion of an excavation checklist by the CP, TTI cleared each new monitoring well location of any subsurface utilities to a depth of approximately 5 feet bgs via air vacuum excavation and air knife. For monitoring well location P-20, four additional holes surrounding the central location (for the installation of protective bollards) were also air vacuum excavated and air knifed for the installation of protective bollards around the completed well.

3.1.2 Borehole Advancement

Borehole advancement for the new monitoring wells was completed from April 14 to 16 and April 21 and 22, 2014, by TTI using hollow-stem auger drilling methods. The borings were completed in overburden material and advanced to depths ranging from 37 to 53 feet bgs as shown in Table 3.1.3. Continuous soil samples were collected in advance of the augers with a split-spoon sampler, and the collected soil samples were screened for the presence of organic vapors using a portable photoionization detector (PID) equipped with a 10.6 electron-volt lamp. The soil was logged by a CB&I geologist in accordance with the Unified Soil Classification System. Observations of impacts during borehole advancement including hydrocarbon odor and gray to black staining occurred in only MRTW-11 with the highest PID reading exhibiting a concentration of 51.76 parts per million in the 13- to 15-foot bgs interval. Boring logs are included in Appendix C.

During drilling on April 14, 2014, the advancement of the borehole for Monitoring Well MW-105 was stopped at 28 feet bgs and a 10-inch diameter steel surface casing was set from near ground surface to a depth of approximately 29 feet bgs and grouted into place. Drilling was re-commenced on April 21, 2014, after the grout had sufficient time to cure. The purpose of this surface casing is to prevent shallow groundwater in the vicinity of the well from being introduced into the deeper groundwater-bearing zone through vertical migration via the borehole.

3.1.3 Well Completion

After reaching the targeted depths, the borings were converted to permanent monitoring wells. The wells were constructed using sections of 2-inch diameter, Schedule 40 polyvinyl chloride (PVC) riser, flush-threaded with 10-foot lengths of 0.010-inch machine-slotted, Schedule 40 PVC screen. The borehole annuli were filled to a depth of approximately 2 feet above the tops of the screen with 20/40 grade clean silica filter sand. A bentonite seal was placed above the filter pack and followed by the surface completion. Monitoring Wells MW-105, MW-106, and MRTW-11 were completed at grade, with flush-mount metal vaults set into concrete pads flush with the ground surface. Monitoring Well P-20 was completed as a stick-up well, with a steel protective casing and locking lid at an elevation of approximately 2 feet above ground surface and protected by concrete bollards. Well completion details are summarized below and are depicted graphically on the boring logs include as Appendix C.

Table 3.1.3: New Well Boring and Completion Depths

Well ID	Location/ Area	Total Boring Depth (feet bgs)	Screened Interval (feet bgs)	Surface Casing Interval (feet bgs)	Well Completion
MW-105	Tar Plant	52.5	41 – 51	0.5 – 29	Flush-mount
MW-106	Keystone	39	28 – 38	N/A	Flush-mount
MRTW-11	Motor Repair Shop	37	27 – 37	N/A	Flush-mount
P-20	Peters Creek	53	42 – 52	N/A	Stick-up

3.1.4 Well Development

The new monitoring wells were developed over an 11-day period in late April 2014. Development consisted of sustained pumping of water from the wells, with additional use of manual surging designed to agitate solids into suspension so as to be removed with the purge water. During development, a multi-parameter meter and electronic turbidity meter were used to periodically measure pH, conductivity, dissolved oxygen, oxygen reduction potential, and turbidity of the purge water.

A total of 35 gallons (20 well volumes) of water was purged from MRTW-11 on April 17, 2014, which entailed pumping the well dry three times. Well development continued on April 23, 2014, for a total volume of 89 gallons purged. The total well depth at the start of development was 36.25 feet below top of casing (btoc); the depth at the end of development was 36.32 feet btoc (approximately 37 feet bgs, as drilled).

A total of 55 gallons of water was purged from P-20 during development on April 23 and 25, 2014. Turbidity at the start of development was above the range measureable by the instrument;

at the end of the development period, turbidity had stabilized at 120 to 130 nephelometric turbidity units (NTU). Total well depth at the end of development was 53.27 feet btoc.

On April 25, 2014, a total of 22 gallons of water was purged from MW-105 during development. Final turbidity was 41.5 NTU, with total well depth increasing over the course of development from 49.95 feet btoc to 50.00 feet btoc.

On April 25, 2014, MW-106 was surged and pumped dry five times; measured turbidity in the purge water remained above 1,000 NTU at the end of this time. Development was continued on April 28, 2014, with the well purged dry again and allowed to recover. Low-flow sampling was conducted after the well had recovered; final turbidity measured 52.4 NTU at the time of sampling.

3.1.5 Groundwater Sampling

Depth-to-groundwater measurements were obtained from the new monitoring wells, and groundwater samples were collected as part of the quarterly sampling events. The details regarding the quarterly groundwater monitoring activities are discussed in detail in Section 3.2 and the results of those monitoring activities are presented in Section 4.0.

3.1.6 Well Surveying

On January 9, 2015, a Pennsylvania-licensed surveyor from Kucera surveyed the locations and elevations of new monitoring wells and repaired wells using a survey-grade (within 0.05-foot horizontal and vertical accuracy) Topcon Global Navigation Satellite System receiver. The survey activities included observations of site benchmarks as needed for datum consistency. Each well was surveyed for its ground elevation and its top of casing or reference elevation in feet above msl. These data were subsequently used for the generation of groundwater elevations.

3.2 Quarterly Groundwater Monitoring Activities

3.2.1 Shallow Groundwater Monitoring Activities

Section 5.1.1 of the GCWP recommended that the sampling network be expanded to include Wells MW-99, TW-51, TW-59, TW-61, TW-82, TW-84, TW-85, RW-94, CYMW-2, and CYMW-9 and new Monitoring Wells MW-106, MRTW-11, and P-20. As part of the GCWP implementation, CB&I completed the groundwater monitoring activities of these wells added to the monitoring while Veolia Water continued with their existing contract to complete U. S. Steel's previous Groundwater Monitoring Program (select wells bimonthly and quarterly). All efforts were made by the groups to coordinate monitoring and sampling activities as near as practicable. From April 15 to 22, 2014 (corresponding with U. S. Steel's Second Quarter 2014 sampling event); July 15 to 17, 2014 (corresponding to U. S. Steel's Third Quarter 2014 sampling event); October 6 to 10, 2014 (corresponding to U. S. Steel's Fourth Quarter 2014 sampling event); and January 12 to 16, 2015 (corresponding to U. S. Steel's First Quarter 2015 sampling event); CB&I gauged the groundwater elevation and sampled most of the wells added to the network using low-flow methodology, in accordance with USEPA guidance (Yeskis and Zavala, 2002). Specific exceptions to this methodology are as noted below.

- In the Keystone Area, TW-82 contained insufficient water for low-flow sampling and was sampled using a bailer. The well was pumped dry at the low-flow sampling rate and took approximately 24 hours to recover.
- In the Oil Seep Investigation Area, RW-94 contained free product and was not sampled.
- In the Crane Yard Area, Monitoring Well CYMW-9 was too close to active railroad tracks to be sampled safely, and Monitoring Well CYMW-2 contained insufficient water for sampling; nearby Monitoring Well CYMW-8 was also dry. Nearby shallow Monitoring Well CYMW-7 was sampled as an alternate to CYMW-2 (Figure 2). As a result of containing an insufficient of volume of water for sampling, CYMW-2 and CYMW-8 were subsequently properly abandoned (Section 3.4.2).

The results of the quarterly sampling of these wells are discussed in Section 4.0. Copies of the laboratory analytical reports are included in Appendix D.

3.2.2 Vertical Groundwater Plume Delineation

In order to determine if shallow groundwater impacts extend downward into the deep groundwater zone, it was recommended in Section 5.1.2 of the GCWP that the following existing monitoring wells be added to the quarterly sampling program: TW-58, TW-66, TW-67, TW-68, TW-75, and TW-93. In addition, a new deep monitoring well, MW-105, was installed to assess deep groundwater conditions in the Tar Plant Area (as described in Section 3.1). The results of the quarterly sampling of these wells are discussed in Section 4.0.

3.3 Repair and Protection of Existing Monitoring Wells

3.3.1 Wellhead Protection

Section 5.1.3 of the GCWP recommended the use of protective bollards around stick-up wells adjacent to roadways and other high vehicular traffic areas. Out of concern for the potential for encountering underground utilities while installing protective bollards for wellhead protection, U. S. Steel requested a variance from PADEP to enable the use of concrete Jersey barriers rather than bollards, which would offer equivalent or superior protection without the need for subsurface excavations. The request was approved by PADEP via electronic mail dated July 29, 2014.

On October 13, 2014, concrete Jersey barriers were strategically placed in order to protect Monitoring Wells MW-29 (in the BTX Plant Area), TW-67 (in the Coal Storage Area), P-4S and

P-4I (in the Peters Creek Coke Yard Area), and P-3S and P-3D (in the Peters Creek Coke Yard Area) from vehicular traffic.

3.3.2 Well Redevelopment

On April 29, 2014, Monitoring Wells MW-14 and TW-59 were redeveloped, as recommended in Section 5.1.3 of the GCWP. Approximately 15.4 feet of silt had accumulated in the bottom of the 20-foot screened interval within Well TW-59. This well was redeveloped by extracting a total of 58 gallons of water and silt. This resulted in the removal of approximately 13.6 feet of silt that had accumulated within the well.

Approximately 20 gallons of very turbid water were removed from Monitoring Well MW-14 before it was pumped dry, resulting in the removal of approximately 2 to 3 inches of coal fines. A comparison with the boring log indicates that nearly 8 feet of silt remains in the 10-foot length of well. Plant personnel provided CB&I with information that coal from the Coal Storage Area had fallen into the well and is presumed to be the majority of the 8 feet of material remaining within the 10-foot length of screen. The coal could not be removed with the pumping equipment used for development.

In addition, approximately 18 gallons of turbid water were purged from Monitoring Well TW-58 in response to very high turbidity measured during sampling. At the end of this purging, water from the well was visually clear.

3.3.3 General Well Repairs

Replacement well caps were added to 23 wells during implementation of the GCWP. Those wells included P-4S, MW-34, TW-54, TW-55, TW-60, TW-61, TW-81, RW-98, MW-1, MW-23A, MW-37A, MW-39, TW-69, TW-71, MW-101B, MW-104B, P-3S, P-8D, P-8S, P-8I, RW-3A, RW-1A, and RW-2A.

As noted in section 5.1.3 of the GCWP, at some point prior to 2013, the riser of MW-8 had been snapped off, potentially allowing surficial material to enter the well at the riser break. On October 23, 2014, MW-8 was repaired by affixing a Fernco fitting fabricated as an "O"-ring to a 3-inch diameter section of Schedule 40 PVC riser and sliding it into the larger diameter 4-inch riser of MW-8. In addition, MW-14 was in need of a well cap. On October 2, 2014, a compression cap was placed on MW-14, and a flush-mounted manhole cover and concrete pad were placed around the former broken well casing.

3.3.4 Well Locks

Following the January 2015 gauging and sampling event, brass padlocks were placed on either the steel vault lid (for stick-up wells) or the well cap (for flush-mounted wells and/or wells in which the steel vault lid was broken) of 67 wells. Locks were not placed on 44 wells for various reasons. Seven wells were recovery wells in which piping and tubing associated with the pumps prohibited placing locks on the wells. One well (MW-41) is located at a depth of approximately 7 feet bgs inside a vault and could not be accessed. The remaining 36 wells had broken locking lids and riser compression caps which did not accommodate placement of locks. Alternative methods to repair and/or lock those wells are being evaluated and will be completed during the next phase of activities.

3.4 Plugging and Abandonment of Unused or Otherwise Nonfunctional Wells

Section 5.1.5 of the 2013 GCWP recommended the plugging and abandonment of unused, damaged, or otherwise nonfunctional wells because open boreholes represented a potential avenue for the introduction of surface contaminants into groundwater. A list of 52 wells that were candidates for abandonment was presented in the GCWP; the exact locations of many of those wells were unknown and attempts at locating those wells were included as part of implementing the GCWP.

3.4.1 Well Location Activities

THG was contracted to use geophysical techniques to locate wells which were presumed to have been paved over, buried, or previously abandoned and/or destroyed. Eleven buried monitoring wells (CYMW-1, CYMW-3, CYMW-4, CYMW-8, MRTW-1D, MRTW-1S, MRTW-3, MRTW-5, MRTW-9, MRTW-10, and TW-63) were located by THG and CB&I personnel utilizing metal detection and ground penetrating radar methods; the locations of those wells were marked for later abandonment.

Based on historical maps, Monitoring Wells TW-64 and TW-88 are in the location now occupied by the CN Substation, which appears to have been built on top of them, minimizing the chance of infiltration of surface water into those borings. According to plant records, Monitoring Wells P-5D and P-7D were accidentally destroyed during coke destocking operations; they could not be located. Based on the locations shown on former maps, Monitoring Well P-7S is believed to have been destroyed during the closure of the Peters Creek Lagoon; its exact location could not be determined. In addition, former Monitoring Wells MW-40, TW-43 through TW-48, TW-62, TW-86, TW-87, TW-92, CYMW-5, P-5S, P-6D, P-9S, and P-9D could not be located visually using geophysical methods or through an evaluation of historical site plans. Further, the former locations of STM-MW-1, MW-6, MW-9, MW-12, MW-13, MW-13A, MW-20, MW-22, and TW-42 are not indicated in site records and their status remains unknown.

3.4.2 Well Plugging and Abandonment

In September and October 2014, 13 wells (P-4D, P-6S, CYMW-1, CYMW-2, CYMW-3, CYMW-8, MRTW-4, MRTW-7, TW-63, TW-65A, TW-96, TW-76, and TW-77) were plugged and abandoned using a tremie pipe and grout. Per the GCWP, CYMW-2 was to have been monitored and CYMW-7 was to have been abandoned (Section 5.1.5 of the GCWP); however, owing to consistently insufficient water volume for sampling present in CYMW-2, that well was plugged and abandoned, and CYMW-7 was retained as part of the quarterly sampling network (as described in Section 3.2.1).

An attempt was made to abandon TW-95. The well, constructed of stainless steel riser and screen, was bent prohibiting the placement of tremie pipe down the well prior to attempting to pull the casing. While pulling the casing, the riser sheared off at approximately 3 feet bgs and surface gravel caved in over top of the well. Attempts to uncover the well and place tremie pipe into the well were unsuccessful. However, U. S. Steel records identify TW-95 as being abandoned. The procedure for previous abandonment is unknown. Confirmation of the abandonment of TW-95 in place will be completed through review of U. S. Steel records, if available.

Eight wells, in addition to TW-95, remain to be abandoned. CYMW-4 and CYMW-9, located within 6 feet of a railroad spur in the Crane Yard Area, require authorization and permitting by U. S. Steel to lockout the rail. Authorization and permitting for rail lockout is pending.

MRTW-1S, MRTW-1D, MRTW-3, MRTW-5, MRTW-9, and MRTW-10, located in the Motor Repair Shop Area have been paved over; abandonment of those wells requires an additional excavation permit which is currently pending. Given the shallow installation of those wells, MTRW-4 being dry recently, and no identified groundwater impact in the area, U. S. Steel may petition PADEP to leave those wells as they are; they are under asphalt pavement and the migration of surface contaminants is greatly reduced by the presence of an asphalt cap.

3.5 Free Product Recovery

3.5.1 Baildown Testing

During the 2013 site-wide well gauging event, it was noted that several of the monitoring wells at the facility, including Wells MW-23A, TW-74, P-14A, P-14B, PRW-7, and PRW-9, contained thicknesses of light non-aqueous phase liquid (LNAPL) hydrocarbons of greater than 0.5 foot (CB&I, 2013b). It was recommended in Section 5.2 of the GCWP that LNAPL baildown testing be performed in order to provide an indication of the recoverability of residual free product in the formation.

LNAPL baildown tests were performed in July 2014 in two wells at the plant: Monitoring Wells TW-74 and P-14B. For each of these tests, initial depths to product and to water were obtained using an electronic interface probe. Free product was then removed from the well as quickly as possible while minimizing the removal of groundwater, and the depths to product and to water were monitored thereafter as static fluid level in each tested well equilibrated. This represents a "baildown/slug test" as described in ASTM International (ASTM) standard procedures (ASTM, 2013).

Keystone Area

Monitoring Well TW-74 was selected as a representative test well for this area of the site, based on the measured thickness of free product (0.98 foot on July 15, 2014). On July 15, 2014, a Clean Earth Technology Spill Buddy™ product recovery pump was used to evacuate a total of 1.0 gallon of LNAPL from TW-74, corresponding to all of the volume of LNAPL in the 4-inch well casing of TW-74 and an additional 0.3 gallon (of an estimated 1.0 gallon total) from the filter pack annular material. The volume of free product in the filter pack was estimated using the methodology and estimated filter pack storativity given in the ASTM (2013) guidance.

Based on the product evacuation time, a minimum test duration of 300 minutes was established. After 31 hours, 17 minutes (1,877 minutes) of data collection, full equilibration of the total fluid head had not yet occurred, although the measured depths to water and to product had changed by 0.01 foot or less in the preceding 8 hours.

Peters Creek Coke Yard Area

For the Peters Creek Coke Yard Area, Monitoring Well P-14B, a 2-inch diameter well (containing 1.67 feet of free product), was chosen as the representative test well, based on its location outside the lagoon slurry wall and the measured thickness of LNAPL (1.67 feet). On July 17, 2014, a disposable bailer was used to remove a total of 0.2 gallon of LNAPL from P-14B, corresponding to all of the volume in the well casing and an additional 0.05 gallon (of an estimated 0.8 gallon total) from the filter pack (the Spill Buddy™ pump could not be used due to an obstruction in the well casing.)

Based on the product evacuation time, a minimum test duration of 200 minutes was established. Readings were collected for a total of 5.5 hours (330 minutes total), at the end of which time the test was considered terminated and full equilibration of the total fluid head had not yet occurred.

3.5.2 Use of Absorbent "Socks"

For wells that contained free product but had product thicknesses insufficient for baildown testing and large-scale recovery, the use of absorbent "socks" was recommended in Section 5.2 of the GCWP.

During the October 2014 and January 2015 quarterly groundwater monitoring activities, product thicknesses in Monitoring Wells MW-8, MW-16, MW-39, TW-70, RW-94, MW-103A, P-14A, P-14B, P-15A, and CYMW-6 were gauged using an oil-water interface probe. Absorbent socks were deployed in October 2014. These socks were replaced during the January 2015 monitoring event, and the new product thicknesses measured. The results are discussed in Section 4.0.

3.6 Assessment of Groundwater Recovery Efforts and Requirements

For most of the study areas, assessment of the need for groundwater recovery was contingent on the full delineation of impacted groundwater (Section 3.2). The results of delineation activities, by study area, are provided in Section 4.0. In addition, the following activities were undertaken.

3.6.1 BTX Trench Inspection

U. S. Steel and CB&I personnel conducted a physical inspection of the trench in the BTX Area, starting at Outfall 007 and ending between Monitoring Wells MW-67 and TW-65A (Figure 2). In addition to the physical inspection, engineering drawings were reviewed and groundwater treatment data received (Appendix E). The findings pertaining to the inspection and documents review are discussed in Section 4.2.

3.6.2 Peters Creek Coke Yard Area

In order to gain a better understanding of the history and geology of this study area, documentation of historical investigations and remedial efforts conducted in this study area were reviewed. Specific reports reviewed include the following:

- *Assessment of the Peters Creek Coke Yard Well Recovery System* (KER, 1990a)
- *An Evaluation of In Situ Bioremediation: Peters Creek Coke Yard* (KER, 1990b)
- *Phase I Geophysical Investigation* (Weston Geophysical Corporation, 1990)
- *Phase I and II Slurry Wall Investigation* (WEG, 1996)
- *Remedial Action Plan* (Geraghty & Miller, Inc., 1996)
- *Peters Creek Lagoon Work Plan: Pilot Nitrate Test* (Baker Environmental, 2001)
- *Environmental Indicator Inspection Report for U. S. Steel (Clairton Plant)* (Foster Wheeler Environmental Corporation, 2002)
- *Design Engineer's Report: Wastewater Treatment Plant Groundwater Remediation (Former Peter's Creek Lagoon Area)* (Crouse & Company, 2013)

In Section 5.3.9 of the GCWP, the need for full delineation of groundwater impacts prior to evaluation of enhanced groundwater capture in this study area was stressed. The results of delineation efforts are discussed in Section 4.9; recommendations are provided in Section 5.9.

3.6.3 Statistical Analysis for Determination of Required Groundwater Recovery

In some cases, recommendations regarding the need for groundwater recovery are clearer in the context of concentration trends for those areas. As in the 2013 GCWP, concentration trends over time were assessed using the Mann-Kendall Statistical Test, as recommended in the

Pennsylvania Groundwater Monitoring Guidance Document (PADEP, 2001) and as described in the USEPA guidance (USEPA, 2006). Calculations were conducted using a spreadsheet modified from that used by the State of Wisconsin's Department of Natural Resources (WDNR, 2001). In this test, a "Mann-Kendall Statistic," S, is calculated and compared to the number of sampling events; the sign (positive/negative) and relative value of the statistic establishes the statistical probability of an upward or downward trend in concentrations over time. Copies of the test worksheets of data from those wells selected for statistical analysis are provided in Appendix F.

4.0 Results

Results of groundwater characterization activities are presented by plant study area. For each study area, the results of (1) plume delineation for both the shallow and deep groundwater zones, (2) free product recovery assessment (if applicable), and (3) groundwater recovery assessment are made.

Groundwater analytical results have been submitted in the quarterly updates (April 30, 2014; July 30, 2014; October 30, 2014; and January 30, 2015) and are summarized in Tables 2 and 3 and on Figures 5 (A through C) and Figures 6 (A through C), for the shallow and deep groundwater zones, respectively. Dissolved-phase concentrations of benzene and phenol in groundwater are compared to the respective Act 2 SHS MSC for used aquifers, as reported in units of milligrams per liter (mg/L).

For free product recoverability, literature suggests that non-aqueous phase liquid (NAPL) with a transmissivity of less than 0.015 square foot per day (feet per day per unit foot of thickness, or ft^2/day) is non-recoverable (Beckett and Lungard, 1997), and that NAPL with a transmissivity of less than 0.1 to 0.8 ft^2/day is practically non-recoverable for all intents and purposes (ITRC, 2009).

4.1 Coal Storage Area

4.1.1 Plume Delineation

As shown on Tables 2 and 3 and in Figures 5 (A through C) and Figures 6 (A through C), shallow and deep impacted groundwater plumes do not appear to extend into this area. Concentrations of both benzene and phenol were consistently slightly above or below detection limits in groundwater samples collected from shallow Monitoring Wells MW-14 and MW-15. One exception was the benzene concentration of 0.0097 mg/L in MW-15 during the October 2014 sampling event which was above the statewide health standard (SHS) medium-specific concentration (MSC) of 0.005 mg/L for benzene. This concentration appears to be anomalous as historical concentrations in MW-15 are at or below detection limits with few exceptions.

Samples collected from Wells TW-66 and TW-67, communicating with the deep groundwater zone near the eastern edge of the Coal Storage Area, were also below the respective SHS MSCs for both benzene and phenol. Groundwater samples collected from deep Monitoring Well TW-68, located in the center of the Coal Storage Area, were consistently below detection limits for both benzene and phenol.

Groundwater impacts in both the shallow and deep groundwater zones in the Coal Storage Area have been characterized and delineated indicating that impact to the Monongahela River does not occur in this area.

4.1.2 Free Product Recoverability

No free product has been detected in this area of the facility, and as such, no investigation was warranted.

4.1.3 Groundwater Recovery Assessment

Given the clean groundwater conditions (below SHS MSCs for both benzene and phenol in both shallow and deep groundwater), recovery of groundwater from this area is not required and was not evaluated.

4.2 BTX Plant Area

4.2.1 Plume Delineation

Concentrations of benzene in groundwater samples collected from shallow groundwater Monitoring Well TW-53, as high as 0.863 mg/L in the August 2014 sampling event, located at the western corner of the BTX Plant Area, indicate that dissolved-phase benzene occurs in the shallow groundwater in this study area. Additionally, the results of samples obtained from the BTX Plant Area in relation to the building basement issues discussed in Section 2.3 indicate that the impacted shallow groundwater in this area occurs at or very near the ground surface and extends to the east from TW-53 toward TW-91 (Figures 3A through 3C). Shallow groundwater at or very near the ground surface is evident in the study area. Figures 5A through 5C show a second area of elevated benzene concentrations centered around TW-53. Further delineation and characterization of shallow groundwater in the area of TW-53 and an evaluation of its relationship with the impacts observed in MW-39, if any, is needed. Recommendations are provided in Section 5.2.1.

As noted during the 2014-2015 characterization activities, shallow groundwater monitored at MW-29, in the northern corner of the BTX Plant Area, and MW-31, in the eastern corner of the BTX Plant Area, is impacted by benzene, with maximum concentrations of 0.298 mg/L and 34.8 mg/L, respectively, exceeding the SHS MSC of 0.005. The samples collected from MW-39, located at the center of the of the BTX Plant Area and shallow groundwater benzene and phenol plumes, exhibited the highest concentrations of benzene and phenol at the site with maximum concentrations of 371 mg/L and 76.7 mg/L, respectively, exceeding both the SHS MSCs of 0.005 mg/L for benzene and 2 mg/L for phenol. However, the BTX Trench, constructed to a bottom elevation of 715 to 718 feet msl, is designed to intercept impacted groundwater flowing through this area before it enters the Monongahela River to the northeast, as discussed in Section 4.2.3.

Figures 5A through 5C show an elongated benzene plume centered around MW-39 and extending toward MW-31, near the southeastern extent of the BTX Trench. The BTX Trench, with a length of approximately 1,000 feet extending along the western bank of the Monongahela River from the Coal Storage Area southeastward throughout the length of the BTX Plant Area, provides groundwater recovery coverage through the plume area (Figure 2, Figures 5A through 5C).

Groundwater samples collected from deep Monitoring Well TW-93 during this four-quarter evaluation, near the center of the BTX Plant Area, contained a maximum concentration of 12.6 mg/L of benzene. While 12.6 mg/L represented the highest concentration reported, the results of samples collected during the other three quarterly events ranged from 8.56 mg/L to 11.8 mg/L, confirming the presence of benzene in deep groundwater at concentrations exceeding the SHS MSC. Phenol was also detected in groundwater samples from TW-93, but at concentrations below the SHS MSC of 2 mg/L. In addition, one anomalous detection of benzene at a concentration 0.0053 mg/L was noted in the July 2014 groundwater sample collected from MW-41, located near MW-31. The BTX Trench extends east of MW-41 and likely intercepts impacted deep groundwater flowing through this area given the constructed trench base elevation of 715 to 718 feet msl and deep groundwater elevations in MW-41 and TW-67 occurring between 728 and 731 feet msl. Sampling results from Monitoring Wells TW-66 and TW-67 (Section 4.1) indicate that the impacted deep groundwater plume in the BTX Plant Area does not extend west-northwest into the Coal Storage Area and appears to be localized to the BTX Plant Area.

Given anticipated deep groundwater flow toward the Monongahela River and Peters Creek as shown on Figures 4A through 4C, further delineation of deep groundwater impacts east of TW-93 is required. Additionally, the extent of deep groundwater benzene impacts to the east, south, or north is unknown. Recommendations to address this data gap are provided in Section 5.2.3.

4.2.2 Free Product Recoverability

Free product was only detected in this area during the October 2014 monitoring event, in which 0.16 foot of free product was measured in Monitoring Well MW-39. Given the one-time detection and comparatively low thickness of LNAPL, LNAPL baildown testing was not conducted at MW-39. However, an oil absorbent "sock" was deployed in MW-39 in October 2014; as of January 2015, the product thickness had been reduced to 0.01 foot.

4.2.3 Groundwater Recovery Assessment

Basic calculations using Darcy's Law indicate that the flux of groundwater into the BTX Trench is on the order of 28,000 gallons per day (gpd). Specifically,

$$Q = -K*A\ (dH/dL)$$

With the input parameters defined and specified in the following table:

Symbol	Value	Units	Description	Source
K	3.17	feet./day	Hydraulic conductivity	Pumping test results from TW-73
X	1,000	feet	Length of trench	U. S. Steel Drawing W46494
b	25.7	feet	Saturated thickness of aquifer	Gauging data for Monitoring Well TW-93
A	22,500	ft^2	Cross-sectional area of flow	Length, X, multiplied by saturated thickness, b
dH	24.28	feet	Change in hydraulic head	Water surface elevation difference between groundwater in MW-39 and water stage in the Monongahela River
dL	460	feet	Length over which change in head is measured	Distance from MW-39 to the Monongahela River in the direction of groundwater flow
Q	28,160	gpd	Groundwater flux into trench	7.48 conversion factor from ft^3/day to gpd

A review of records of water recovered by the trench for treatment (Appendix E) indicates that there was minimal recovery of water from the trench in 2012-2013 as a result of comparatively low concentrations of benzene and phenol in the samples collected from the trench. Concentrations of both benzene and phenol in groundwater increased in February 2014 and reached a peak of over 500 mg/L benzene and 76.6 mg/L phenol in early March 2014. Recovery of groundwater from the trench was increased by U. S. Steel in March through June 2014, with maximum extraction rates reaching as high as 35,000 gpd (i.e., pulling in water from outside the area immediately upgradient) in May 2014.

By June 2014, measured benzene concentrations in trench water samples had been reduced by over 97 percent (to 17.3 mg/L) and continued to decline, and the extraction rate was reduced to 100 to 300 gpd (U. S. Steel, 2014).

Because the water level within the trench is intentionally kept at a lower elevation than the pool elevation in the Monongahela River, it is unlikely that water is escaping from the trench into the river. Therefore, during periods when the trench extraction rate is less than 28,160 gpd, the excess groundwater not captured flows around the sides of and/or backs up behind the trench. This condition is reflected in the shape of the nearby groundwater flow lines depicted on Figures 3A through 3C.

A non-parametric statistical analysis (Mann-Kendall test) conducted on the data from samples collected from MW-39 (the most highly impacted well in the study area) indicates a stable concentration trend. However, the statistical evaluation of data from samples collected from Monitoring Wells MW-29, MW-31, and MW-41 shows non-stable statistical trends (oscillating upward and downward), as shown in Appendix F. In summary, the BTX Trench is capturing impacted groundwater as designed.

4.3 Tar Plant Area

4.3.1 Plume Delineation

As shown on Figures 5A through 5C, the benzene isoconcentration lines for samples from the shallow groundwater zone in this study area are relatively close together and contained to a relatively small area around Recovery Well RW-26. This is a result of the ongoing groundwater recovery efforts in the area (Section 4.3.3) and is not expected to change unless pumping is interrupted.

Samples collected from Recovery Well RW-26 exhibited the highest concentrations of benzene and phenol in the shallow groundwater zone within this study area with concentrations of 22.4 mg/L and 11.0 mg/L, compared to the SHS MSCs of 0.005 mg/L and 2.0 mg/L, respectively. Benzene concentrations in samples from MW-37A, while above the SHS MSC, appear to be controlled by the recovery well system. Shallow groundwater samples collected from MW-30, MW-32, and MW-33 indicate that the benzene and phenol plumes do not extend beyond the Tar Plant Area and are localized to the area immediately surrounding the recovery well system. Shallow groundwater impacts in the Tar Plant Area have been characterized and delineated.

New Monitoring Well MW-105 was installed in 2014 to assess whether deep groundwater in this area has been impacted. Concentrations of phenol in all four of the quarterly samples were below detection limits. A concentration of 0.0153 mg/L of benzene was detected in the groundwater sample collected in April 2014 from MW-105; however, the results from three subsequent quarterly samples have been below detection limits. Deep groundwater does not appear to be impacted in the Tar Plant Area and has been characterized and delineated.

4.3.2 Free Product Recoverability

In July 2014, free product was measured in shallow Monitoring Wells RW-26 and RW-38; total product thickness in each well was less than or equal to 0.01 foot. This product thickness was insufficient to conduct a LNAPL baildown test. During the October 2014 and January 2015 gauging events, no free product was measured in these wells.

In May 2013, Monitoring Well MW-23A, located near Recovery Well RW-26, contained 0.57 foot of free product; however, this well was not included in the 2014 quarterly gauging and sampling conducted at the site.

4.3.3 Groundwater Recovery Assessment

Quarterly gauging of the monitoring wells in this area indicates that the cone of depression created by Recovery Well RW-38 remains well established (Figures 3A through 3C). Although Recovery Wells RW-26 and RW-27 do not appear to be fully contributing to the cone of depression in the area, as noted in the GCWP, the capture nevertheless appears to be adequate. According to reports received from U. S. Steel, new groundwater recovery pumps were last installed in recovery wells in this study area in December 2004 and put into operation on March 30, 2005; currently, the pump in RW-27 is not running (U. S. Steel, 2014). Recent quarterly summary reports generated by U. S. Steel also indicate that a bailer is stuck in RW-38, prohibiting the collection of groundwater samples and depth-to-water measurements.

Non-parametric tests of concentrations over time (Mann-Kendall tests) were conducted on the benzene data collected from 2011 through 2014 in samples from Wells RW-26, MW-33, MW-34, and MW-37 and for phenol data in samples from Wells RW-26, RW-27, and RW-38 (Appendix F). A decreasing concentration trend (at a 90 percent statistical confidence level) for benzene was noted for MW-37A; however, the data from MW-34 indicated an increasing trend (at an 80 percent statistical confidence level). Benzene concentration data from RW-26 were statistically stable, and data from MW-33 indicated oscillating concentrations with no trend.

Phenol data from all three of the recovery wells indicated decreasing trends at the 90 percent statistical confidence level.

Recommendations, based on the results available, are provided in Section 5.3.

4.4 Oil Seep Investigation Area

4.4.1 Plume Delineation

Laboratory analytical data indicate that groundwater in the vicinity of Monitoring Well MW-99 is impacted by benzene, with a maximum concentration of 0.041 mg/L reported in the sample collected in July 2014. Detectable concentrations of phenol have also been noted but at concentrations below the SHS MSC. Dissolved-phase benzene concentrations in groundwater samples collected from Recovery Well RW-94, along the river wall to the west of MW-99, were below the SHS MSC for all sampling events with the exception of the April 2014 event, when a benzene concentration of 0.0245 mg/L was detected. Given the small size of the Oil Seep Investigation Area and the location of MW-99 near the river wall and Monongahela River, further characterization and delineation of impacted shallow groundwater in this area is not required.

Given the current, existing monitoring well network in the area and results of past investigations, deep groundwater in this area is not impacted and does not require further delineation or characterization.

4.4.2 Free Product Recoverability

In July and October 2014 and in January 2015, 0.01 foot of product was measured in Recovery Well RW-94. This product thickness was insufficient for conducting a LNAPL baildown test.

4.4.3 Groundwater Recovery Assessment

There are four separate wells at the location indicated as "RW-94" on Figure 2, one of which contains a pump that operates intermittently; these wells contain free product, believed to be the source of the impacts in MW-99. It is important to note that boring log and/or monitoring well construction details for Wells RW-94 and MW-99 are not available. A review of drawings of the river wall construction indicates that the river wall acts as a barrier to shallow groundwater discharge at the site as shown on Cross Sections A-A' through C-C' (Appendix B-2). However, the deep groundwater zone appears to be in direct communication with the Monongahela River as indicated by the bottom of the river wall being constructed into the top of the deep groundwater-bearing zone (sand and gravel). Hydrographs generated during the "*Phase II Well 7 Area Study*" confirmed that the Monongahela River communicates with the deep groundwater zone, but not the shallow groundwater zone (KER, 1991b). Based on the groundwater flow barrier in the shallow groundwater zone and concentrations of benzene in samples from Well MW-99, recommendations for the Oil Seep Investigation Area are provided in Section 5.4.

4.5 Keystone Area

4.5.1 Plume Delineation

The extent of impacted shallow groundwater in this study area is primarily centered around Monitoring Well TW-55, as shown on Figures 5A through 5C. Delineation of the impact within this area has been completed by the addition of Monitoring Wells TW-51, TW-59, TW-61, TW-82, and MW-106 in addition to the results of samples collected from wells in adjacent study areas (Second Unit Coking Area and Oil Seep Investigation Area) (Figure 2 and Figures 5A through 5C). Concentrations of benzene and phenol in groundwater samples collected from the six monitoring wells identified above have been below detection limits for the four quarters of sampling data, with the following exceptions:

- The April 2014 sample from TW-51 contained 0.0051 mg/L benzene compared to the SHS MSC of 0.0050 mg/L; this detection was not repeated in subsequent sampling events.
- The January 2015 sample from MW-106 contained 0.0186 mg/L benzene. Concentrations of benzene in previous samples (April, July, and October 2014) collected from this well have been consistently below detection limits.

Additionally, benzene concentrations in samples from Monitoring Well TW-85, located along the boundary with the Second Unit Coking Area (Figure 2 and Figures 5A through 5C) have been reported at concentrations slightly above the SHS MSC.

However, free product was found in Well TW-74 (Section 3.5.1) and groundwater gathered during LNAPL baildown testing in TW-74 showed olfactory indications of impacts. It is possible that the benzene and phenol plume around TW-55 extends to and is inclusive of TW-74. The approximate location of the old Peters Creek stream channel, as interpolated from the 1907 topographic map prior to its being relocated, is near TW-74 and TW-85 and is a potential preferential pathway of shallow and deep groundwater flow toward the Monongahela River. TW-74 was not sampled due to the occurrence of free floating product in the well. Delineation of those impacts in TW-74 as they relate to the old Peters Creek stream channel requires further investigation and characterization. Several existing wells nearby can be utilized to accomplish this, and those recommendations are provided in Section 5.5.

Shallow Monitoring Wells TW-51 and TW-61, located downgradient of TW-74, were added to the quarterly groundwater monitoring regime (Section 3.2); dissolved-phase benzene concentrations in groundwater samples collected from both of these wells are below the SHS MSC with the exception of the April 2014 TW-51 sample as discussed above. Shallow Monitoring Well TW-85 is located side-gradient of TW-74 (Figures 3A through 3C). Benzene concentrations in groundwater samples from TW-85 are slightly elevated, as noted above. However, concentrations in groundwater samples from Monitoring Well TW-82, located between TW-85 and the Monongahela River, are below detection limits.

Deep Monitoring Wells TW-58 and TW-75 were added to the quarterly monitoring program. These wells provided monitoring points completed in the deep groundwater zone in the Keystone Study Area. Concentrations of benzene and phenol in groundwater samples from both of these wells were below detection limits (Table 3), confirming that deep groundwater in the vicinity of those wells within the Keystone Area have not been not impacted by these constituents.

Given historical investigations in this area, confirmation of the benzene and phenol impacts observed in deep Well TW-60 in 1991 would be prudent, especially given the communication between the deep groundwater-bearing zone and the Monongahela River as determined during the KER "*Well 7 Area Study Phase II Report*," the occurrence of free product in TW-74, and the approximate location of the old Peters Creek stream channel through this area. Recommendations for delineation of deep groundwater in this area are provided in Section 5.5.

4.5.2 Free Product Recoverability

As noted in Section 3.5.1, baildown testing was conducted on Monitoring Well TW-74, which contained nearly 1 foot of free product. A curve match for the test data was obtained using the

Bouwer and Rice (1976) unconfined method, per the ASTM guidance for the analysis of slug tests (ASTM, 1996). AQTESOLV® for Windows, Version 4.50 software (Duffield, 2007) was used to facilitate the curve matching. The curve match obtained corresponds to a transmissivity of approximately 0.01 ft^2/day.

Shallow Monitoring Well TW-74 has historically contained free product. Recommendations for product recovery from this well are provided in Section 5.5.

4.5.3 Groundwater Recovery Assessment

Analytical results of samples collected from TW-55 over the period from 2010 through 2014 indicate an increasing trend in shallow groundwater benzene and phenol concentrations at that location (Appendix F). However, the overall areal extent of the benzene and phenol plume centered on Monitoring Well TW-55 is relatively small, based on available data as shown on Figures 5A through 5C.

Former Recovery Well RW-98 is located within the plume but is not currently in operation. The decreasing statistical trend for dissolved-phase benzene concentrations in samples collected from RW-98 (80 percent statistical confidence level) is likely attributed to the migration of benzene-impacted groundwater toward TW-55. Given that the results of benzene and phenol concentrations in samples collected from downgradient Wells TW-61 and TW-82 have been below detection limits, groundwater recovery does not appear to be warranted at this time. Recommendations are provided in Section 5.5.

4.6 Second Unit Coking Area

4.6.1 Plume Delineation

A sheen of LNAPL was present within Monitoring Well MW-8, located near the southwest edge of this study area in 2013. However, groundwater samples collected from MW-8 in 2014 are below the SHS MSC for benzene (Table 2), indicating that the free product detected in the well is unrelated to the specific concerns of the 2013 COA and may be biologic. Regardless, limited product recovery was undertaken (Section 3.6.2).

In 2013, new quenching towers were constructed in this study area. Benzene concentrations from water recovered during the dewatering process ranged from 0.0195 mg/L to 0.141 mg/L; phenol concentrations in the recovered water reached a concentration of 0.211 mg/L. The location of MW-8 upgradient of the construction area presents no immediate impact on groundwater in the area.

4.6.2 Free Product Recoverability

No free product was measured in this area in 2014. Based on the initial detection of a sheen in Monitoring Well MW-8 in May 2013, an absorbent sock was deployed in October 2014 at that location. As of January 2015, no free product was measured in MW-8.

4.6.3 Groundwater Recovery Assessment

With the quenching tower project being completed and located downgradient of unimpacted MW-8, additional information is not required at this time.

4.7 First Unit Coking Area

4.7.1 Plume Delineation

Monitoring Well MW-5 continues to be sampled on a quarterly basis. Concentrations of both benzene and phenol in groundwater samples collected from MW-5 continue to be below their respective SHS MSCs (Table 2), indicating that no impacted groundwater exists in this area and shallow groundwater has been characterized in this area.

4.7.2 Free Product Recoverability

No free product has been detected in this area of the facility.

4.7.3 Groundwater Recovery Assessment

Given the clean groundwater conditions (concentrations of benzene and phenol below detection limits), there is no need for groundwater recovery from this area.

4.8 Steel Works Area

4.8.1 Plume Delineation

Based on the results of analysis of groundwater samples collected from Monitoring Wells MW-1 through MW-4, benzene and phenol concentrations in area groundwater are below detection limits. Shallow groundwater has been characterized in this area.

4.8.2 Free Product Recoverability

No free product has been detected in this area of the facility.

4.8.3 Groundwater Recovery Assessment

Given the unimpacted groundwater conditions (samples from this area were below detection limits for both benzene and phenol), there is no need for groundwater recovery from this area at this time.

4.9 Peters Creek Coke Yard Area

4.9.1 Plume Delineation

Concentrations of benzene and phenol in groundwater samples collected from wells located outside of the slurry wall indicate that residual tarry material may still remain in the subsurface and impacted groundwater immediately outside of and around the slurry wall. Impacted groundwater is present outside of the slurry wall to the northwest, downgradient, in the direction of Peters Creek as evident by the concentrations of benzene in the sample collected from TW-71 (4.97 mg/L in April 2014). Groundwater samples containing benzene concentrations above the SHS MSC include those collected from shallow Monitoring Wells MW-16, MW-17, TW-70, TW-71, MW-103A, and OW-1 through OW-4. Phenol concentrations in samples collected from OW-1 also exceeded the SHS MSC of 2.0 mg/L during all four quarters in which the GCWP implementation occurred, with a maximum concentration of 2.26 mg/L in the July 2014 sample. Although groundwater from these nine locations is impacted, groundwater samples collected from downgradient Well TW-69, located the farthest northeast of the former Peters Creek Lagoon, were below the SHS MSCs for benzene and phenol indicating that impacted groundwater does not extend to the north toward TW-69. However, there are no groundwater monitoring wells northwest and west toward Peters Creek, nor southeast toward the Coke Storage Area of those wells listed above, and further horizontal and vertical delineation in those directions is required.

Groundwater samples collected from deep Monitoring Wells P-1I and MW-103B, located outside the slurry wall, also contained benzene concentrations that exceeded the SHS MSC. The maximum concentrations of benzene in samples collected from Wells P-1I and MW-103B were 0.0077 mg/L and 0.0335 mg/L, exceeding the SHS MSC of 0.005 mg/L. These results indicate that deep groundwater is impacted by benzene at locations immediately outside of the slurry wall. Phenol concentrations from all deep groundwater samples collected at the Peters Creek Coke Yard were below the phenol SHS MSC, with a majority of the samples being below detection limits.

Groundwater collected from shallow Monitoring Wells TW-69 and P-20 contained concentrations of both benzene and phenol less than their respective SHS MSCs (Table 2), providing area delineation to the northeast and southwest, respectively. Groundwater in the vicinity of MW-17, located on the southeast border of the study area, appears to be impacted with concentrations of benzene that exceed the SHS MSC. These results imply that impacted shallow groundwater may extend for a limited distance upgradient to side-gradient in that direction (Figures 3A through 3C). An increasing benzene concentration trend (90 percent statistical confidence level) is noted for the data from MW-17 over the period from 2010 through 2014, with the highest concentration during that time period occurring during the August 2014 sampling event with a concentration of 0.513 mg/L benzene.

Further delineation of the benzene and phenol impacts to shallow groundwater located along the outside of the former Peters Creek Lagoon from the location of Well OW-1 toward MW-17 is warranted. In particular, delineation of shallow impacts to the west toward Peters Creek and to the east toward MW-17 is needed to better identify the nature and extent of those impacts. Recommendations for additional work to define shallow groundwater impacts are provided in Section 5.9.

Benzene concentrations in groundwater samples collected from deep Monitoring Wells MW-101B, MW-102B, MW-104B, P-4I, and P-8I are below the SHS MSC of 0.005 mg/L, and phenol concentrations in these wells are less than the SHS MSC of 2.0 mg/L. In addition, the lateral extent of deep groundwater impacts in the vicinity of MW-103B, at the upgradient (southern) edge of the former Peters Creek Lagoon, is delineated in the east by Monitoring Well P-4I (Table 3 and Figures 5A through 5C). The proximity of Wells MW-103B and P-4I in conjunction with head measurements and benzene concentrations indicates that the anticlinal plunge to the southwest could be influencing groundwater flow in the deep groundwater-bearing zone. As a result, further delineation of deep groundwater concentrations observed in MW-103B to the southwest and west is warranted. Recommendations for delineation of deep groundwater impacts are provided in Section 5.9.

4.9.2 Free Product Recoverability

As shown in Table 4, shallow monitoring wells in this area containing free product in October 2014 included MW-16 (0.20 feet), TW-70 (0.02 feet), MW-103A (0.01 feet), P-14A (0.17 feet), P-14B (0.90 feet), and P-15A (0.03 feet). Wells P-14A and P-15A are located within the area surrounded by the slurry wall. The other four wells are at locations outside the confines of the slurry wall.

LNAPL baildown testing was conducted on Monitoring Well P-14B, as described in Section 3.5.1. The data were analyzed using the Cooper-Bredehoeft-Papadopulous (1967) solution for slug tests in confined aquifers, per the ASTM guidance for slug test analyses (ASTM, 1996). The automatic curve match function in AQTESOLV® for Windows, version 4.5 (Duffield, 2007) provided a very close curve match, which corresponds to a transmissivity of approximately 0.007 ft^2/day.

In October 2014, absorbent "socks" were deployed in the wells with the greatest product thicknesses (P-14A, P-14B, and P-15A). As of January 2015, product thickness in Monitoring Well P-14A had been reduced to 0.03 foot, and no free product was detected in P-14B or P-15A. In addition, no free product was detected in MW-16, TW-70, or MW-103A in January 2015.

4.9.3 Groundwater Recovery Assessment

Analytical results of groundwater samples collected from new Monitoring Well P-20, located west-southwest of the former lagoon (Figure 2), indicate that groundwater impacts associated with the former lagoon do not extend to that point, and therefore, do not reach the sections of Peters Creek located farther upstream to the west (Figures 5A through 5C).

Records review (Section 3.6.2) indicates that the Peters Creek Seep Collection Trench is a 70-foot-long French drain located northwest of the former Peters Creek Lagoon, along the eastern bank of Peters Creek. Groundwater seepage from the former Peters Creek Lagoon is intercepted by the trench and collected into a sump, where it is pumped to a treatment system. The recovery rate was estimated at 15 to 20 gallons per minute (Baker Environmental, 2001). Treatment is by passage through bag filters and twin carbon vessels; treated water is discharged by permit at Outfall 090 into Peters Creek.

The distance between shallow wells that contain groundwater impacted by benzene (located north-northwest of the former Peters Creek Lagoon, between the former Peters Creek Lagoon and Peters Creek) is approximately 800 feet as measured from TW-71 to OW-3. Further, a number of seeps have been identified on the hillside along that 800-foot distance between TW-71 and OW-3. The existing 70-foot-long Peters Creek Seep Collection Trench is located farther northeast of OW-3 and while this trench may be working as designed, the location and hydraulic reach may not effectively address recovery of impacted groundwater in this study area at locations farther upstream (toward TW-71).

Samples of surface water discharging from the Peters Creek Outfall into the Monongahela River are collected on a daily basis and analyzed for benzene and phenol, as part of the facility's Early Warning System described in the 120-Day Compliance Summary Report (CB&I, 2013a). Early Warning System data are reported to PADEP by U. S. Steel on a quarterly basis (e.g., *Consent Order and Agreement: Clairton Works Benzene Study and Third Amendment to Consent Order, Peters Creek Lagoon Investigation, 3rd Quarter 2014 Progress Report* [U. S. Steel, 2014]). Based on a review of the quarterly reports for 2014, there were no exceedances of the respective SHS MSCs in the outfall samples. The maximum concentration of benzene measured at the Peters Creek Outfall in 2014 was 0.0038 mg/L in the sample collected on August 21, 2014. That sample also exhibited the maximum concentration of phenol (0.010 mg/L, compared to the SHS MSC of 2.0 mg/L).

The low concentrations measured at the mouth of Peters Creek imply that either:

(a) If impacted groundwater is discharging to Peters Creek, mixing within the stream reduces concentrations to those shown; or

(b) Peters Creek is a "losing stream" which, overall, contributes to groundwater more than it is fed from groundwater, especially in the vicinity of the former lagoon.

In the latter case, groundwater concentrations at the former Peters Creek Lagoon would not contribute to surface water concentrations. However, given the shallow depth to groundwater near Peters Creek (approximately 735 feet msl at Monitoring Well TW-71, as compared to a Peters Creek approximate creek elevation of 730 feet msl), this scenario is unlikely. Confirmation of head measurement in this area is recommended (Section 4.9). Historically a number of seeps have been identified along the eastern bank of Peters Creek and are a further indication that Peters Creek is a gaining stream. The current status of these seeps is unknown and an assessment of these seeps would aid in characterization of impacts associated with the former Peters Creek Lagoon.

Statistical tests of concentrations over time were conducted on benzene data generated from samples collected from MW-16, OW-1 through OW-4, and TW-71 and on phenol data from samples collected from OW-1, OW-4, and MW-103A (Appendix F). Dissolved-phase benzene and/or phenol concentrations associated with OW-2 and OW-4 showed a decreasing trend. Benzene concentrations associated with MW-16 were non-stable. Benzene concentrations associated with TW-71 and OW-1 were stable, although with a wide amount of variation between some consecutive samples. Benzene concentrations associated with OW-3 were increasing at a 90 percent statistical confidence. Wells OW-3, OW-2, and TW-71 are the only monitoring points between the former Peters Creek Lagoon and Peters Creek; elevated concentrations in samples collected from these wells indicate that further delineation of groundwater impacts closer to Peters Creek should be completed. Recommendations for further delineation are discussed in Section 5.9.2.

4.10 Motor Shop Repair Area

4.10.1 Plume Delineation

Concentrations of both benzene and phenol in groundwater samples from Monitoring Well MRTW-11 were below their respective detection limits (Table 2), indicating that no impacted groundwater exists in this area.

4.10.2 Free Product Recoverability

No free product has been detected in this area of the facility.

4.10.3 Groundwater Recovery Assessment

Given the clean groundwater conditions (benzene and phenol concentrations below detection limits), there is no need for groundwater recovery from this area.

4.11 Crane Yard Area

4.11.1 Plume Delineation

Although free product was detected in Monitoring Well CYMW-6 in 2014, benzene and phenol concentrations in groundwater samples collected from nearby Monitoring Well CYMW-7 (approximately 100 feet to the south) have been consistently below detection limits. Therefore, any groundwater plume associated with the free product is isolated to the CYMW-6 area.

4.11.2 Free Product Recoverability

Monitoring Well CYMW-6 contained 0.01 foot of free product in 2014. This product thickness was insufficient to conduct LNAPL baildown testing. An absorbent sock was placed into the well in October 2014. As of January 2015, 0.01 foot of free product remained in the well.

4.11.3 Groundwater Recovery Assessment

Given the very limited areal extent of groundwater impacts around CYMW-6 in the Crane Yard Area and the presence of other wells monitoring this shallow groundwater zone, groundwater capture is not considered a priority for the area. Recommendations associated with the existence of 0.01 foot of LNAPL in Well CYMW-6 are presented in Section 5.11.

5.0 Recommendations

Based on the results of the implementation of the GCWP, the following recommendations are offered. Presentation of the recommendations follows the general order of presentation in Section 4.0, by plant study area. In general, the results presented herein identify a number of data gaps to be addressed before the Groundwater Site Characterization Report, as defined in the 2013 COA, can be prepared.

5.1 Coal Storage Area

There appear to be no shallow or deep groundwater impacts in this area. It is recommended that monitoring be continued according to U. S. Steel's existing schedule. No further action is warranted.

5.2 BTX Plant Area

An assessment of the BTX Trench (Sections 3.6.2 and 4.3.2) suggests that the trench provides an important component in preventing impacted groundwater in the BTX Plant Area from reaching the Monongahela River. However, additional work is needed to confirm complete collection of the impacted groundwater emanating from the BTX Plant Area.

5.2.1 Shallow Groundwater Plume Delineation

Benzene and phenol-impacted shallow groundwater exists in two detached plumes in the BTX Plant Area as identified on Figures 5A through 5C. One plume appears to be centered near Well MW-39 and the second area of impact is in the vicinity of TW-53 along the western boundary of the BTX Plant Area. The latter area is being evaluated based on identified shallow groundwater impacts..

The "*Well 10 Area Study Phase II Report*" completed in January 1991 by KER identified three additional wells near TW-53 in which impacted shallow groundwater occurs near the ground surface. This is consistent with water elevations measured in TW-53 and the investigation of shallow groundwater impacts in this study area.

The areal extent of the shallow groundwater zone to the south and west of TW-53 is presently unknown, as is any potential relationship with the impacts observed in MW-39. Further delineation of impacted shallow groundwater in the vicinity of TW-53 can be accomplished with the installation and groundwater sampling of one monitoring well to the south of TW-53; however, the site configuration, railroad tracks, and utilities may present some difficulty in accomplishing this task. Additionally, installing a well between TW-53 and MW-39 would assist in determining if any relationship exists between the concentrations of benzene collected from TW-53 and MW-39.

5.2.2 *Deep Groundwater Plume Delineation*

Groundwater flow is north-northeast toward the Monongahela River and Peters Creek confluence as shown on Figures 4A through 4C. Deep groundwater flow should occur toward the north-northeast, and therefore, deep groundwater Monitoring Wells TW-73 and TW-90 should be sampled to identify if deep groundwater impacts extend through the sand and gravel and flow toward Peters Creek. Sampling these wells will allow assessment of whether groundwater flows beneath the Peters Creek Arch. Further, the logistics to install wells on each side of the BTX Trench should be evaluated and wells should be installed. Groundwater samples collected from those wells would help determine if deep groundwater impacts extend underneath the BTX Trench.

5.2.3 *Shallow Groundwater Recovery*

MW-39 is located near the center of the groundwater benzene and phenol plume in the BTX Plant Area within the shallow groundwater-bearing zone. In September 1993, MW-39 was converted to a recovery well and re-designated RW-39; it was operated as such until a recent determination was made that it was incapable of the well efficiencies needed to maintain its use as a recovery well, and a decision was made to re-assess the need for installation of a designated recovery well in the area. Pumping in RW-39 was suspended and the well was re-designated MW-39 (U. S. Steel, 2014).

Sampling results from shallow groundwater monitoring wells in the area (Table 2 and Figures 5A through 5C) indicate that the shallow groundwater benzene and phenol plumes in that area of the plant remain centered on MW-39 and extend toward the BTX Trench. A thin layer of LNAPL (0.16 foot) was found when monitoring MW-39 in October 2014. In addition, the trend analysis described in Section 4.2 indicates non-stable or stable concentrations, implying that attenuation is not a meaningful component of plume management in this area at the present time.

Because MW-39 was determined by plant personnel to be unsuitable for use as a recovery well, evaluating the potential need for additional recovery wells near the center of the plume is recommended. If it is determined that the need for additional recovery wells exists, additional investigation in the area will be required to define the locations, yield, radius of influence, and feasibility of recovery wells to augment the existing system.

Additionally, the installation of shallow monitoring wells and sampling of groundwater on the Monongahela River side of the BTX Trench can be used as a means to check the efficiency and effectiveness of the BTX Trench in relation to capturing impacted groundwater before it enters the Monongahela River.

5.2.4 Product Recovery

Given the anomalous nature of the detection of free product in the area, long-term product recovery by means of pumping or skimming is not recommended. The continued use of oil absorbent socks in MW-39 to capture any free product that might accumulate in the well is recommended while the next phase of delineation is implemented. The need for future use of absorbent socks will be re-evaluated as part of the summary report prepared to present the findings of the tasks recommended in this report.

5.3 Tar Plant Area

5.3.1 Shallow Groundwater Recovery

As noted in Section 4.3.3, groundwater capture in the southern part of this area appears to have been consistently maintained throughout the COA implementation activities thus far, and reducing concentration trends are noted for groundwater samples collected from RW-37A. In the event that future groundwater gauging and mapping shows a reduced cone of influence around RW-38 indicating poor system performance, rehabilitation and increased pumping from RW-26 and/or RW-27 should be evaluated. Additionally, as part of ongoing monitoring of the performance of the recovery well system, the bailer which is stuck in RW-38 should be removed for the collection of groundwater samples and groundwater elevations.

5.3.2 Product Recovery

Given the success of the use of absorbent "socks" in reducing free product thickness in other shallow wells at the plant, it is recommended that this method also be adopted for Monitoring Well MW-23A and any other wells in which free product is identified while the next phase of delineation is implemented. The need for future use of absorbent socks will be re-evaluated as part of the summary report prepared to present the findings of the tasks recommended in this report.

5.4 Oil Seep Investigation Area

5.4.1 Shallow Groundwater Recovery

There are four separate wells at the location indicated as "RW-94" on Figure 2, one of which contains a pump that operates intermittently; these wells contain free product, believed to be the source of the impacts in MW-99. It is recommended that the pumping associated with RW-94 be further evaluated, as the impacts noted in samples collected from MW-99 indicate that complete capture is not being achieved at that location by current extraction rates. The evaluation would include determining if an increase in the extraction rate and/or frequency of operation in the existing pumping well and/or by the addition of pumps in one or more of the other wells in the RW-94 cluster is needed.

5.4.2 Product Recovery

Enhanced pumping at the RW-94 recovery well cluster could eventually remove the free product from those wells. As additional product recovery occurs, the depth to water, fluid extraction rate, and volume of product collected should be noted.

5.5 Keystone Area

5.5.1 Shallow Groundwater Plume Delineation

The quarterly sampling of Monitoring Wells TW-51, TW-59, TW-61, TW-82, TW-84, and MW-106 over the past year have delineated the shallow groundwater benzene and phenol plumes centered around TW-55 to the north toward the Monongahela River. However, free product identified in TW-74 and concentrations of benzene in the samples collected from TW-85 (located east of TW-55) indicate perhaps an elongated plume in this area. The relationship between the TW-55 and TW-74 impacts is unknown. In addition, the 1907 topographic map of the area indicates that Peters Creek once flowed through this area prior to its being relocated underneath the Tar Plant Area. The former creek channel is a potential preferential flow path for shallow and/or deep groundwater flow toward the Monongahela River. As such, additional delineation in this area should be conducted.

It is recommended that TW-74 be sampled (placement of an oil absorbent sock in the well should allow a product-free groundwater sample) and sampling of shallow groundwater wells located closest to the old Peters Creek channel (TW-57 and TW-80) downgradient of TW-74 is recommended quarterly for a year. Based on those results, the configuration and extent of the impacted groundwater will be better known and an assessment of remedial alternatives, if necessary, may be viable.

5.5.2 Deep Groundwater Plume Delineation

The quarterly sampling of Monitoring Wells TW-58 and TW-75 over the past year have identified that deep groundwater in those areas is not impacted to the north toward the Monongahela River. As defined in Section 4.5.2, the original location (circa 1907) of the Peters Creek stream channel may influence groundwater flow in both the shallow and deep groundwater zones through this area.

Deep groundwater wells of the nested wells located nearer the old Peters Creek channel (TW-56 and TW-81) should be sampled quarterly for one year for comparison purposes to the shallow zone and to determine potential deep impacts and the influence of the old Peters Creek channel on deep groundwater flow toward the Monongahela River. The sampling of these wells in combination with continued sampling of the wells recommended in the GCWP would provide better coverage and monitoring of both the shallow and deep groundwater zones at most of the wells in the Keystone Area with the exception of the TW-50/51 and TW-82/83 wells in which only the shallow groundwater well is sampled and monitored.

5.5.3 Shallow Groundwater Recovery

Given the relatively small size of the shallow groundwater plume centered on Monitoring Well TW-55, additional groundwater capture is not needed at this time. However, as noted in Section 4.5, benzene concentrations associated with TW-55 show a statistically increasing trend. Continued monitoring of TW-55 and downgradient wells to determine if impacted groundwater is migrating toward the Monongahela River is recommended quarterly for the period that extends to four quarters following the installation of monitoring points and staff gauges proposed in this report. If increases are noted and confirmed by successive results in the downgradient wells, a second recovery well located farther downgradient of RW-98 (i.e., near TW-54, but screened within the shallow groundwater zone) may need to be installed.

The detection of benzene in the January 2015 sample collected from MW-106 is assumed to be anomalous, considering the results of previous samples from that well had been consistently below detection limits. Monitoring of the results of future sampling will be conducted, and if the detection of benzene greater than the SHS MSC is confirmed, additional investigation in that vicinity may be warranted at that time.

5.5.4 Product Recovery

As noted in Section 4.5.2, LNAPL measured in Monitoring Well TW-74 appears to be unrelated to the shallow dissolved-phase plume in the area. LNAPL transmissivity was estimated at 0.014 ft^2/day, compared to a minimum value of 0.015 ft^2/day for sustainable recoverability. Therefore, the prospect for sustainable product recovery by the use of trenches or skimmers is suspect. Given the success of the use of absorbent "socks" in reducing and/or eliminating product in Monitoring Wells P-14A and P-14B (Section 4.9), this method is also recommended for Monitoring Well TW-74 while the next phase of delineation is implemented. The need for future use of absorbent socks will be re-evaluated as part of the summary report prepared to present the findings of the tasks recommended in this report.

5.6 Second Unit Coking Area

As noted in Section 4.6, there appear to be no shallow or deep groundwater impacts in this area. It is recommended that monitoring be continued according to U. S. Steel's existing schedule, but no further action is warranted at this time.

5.6.1 Product Recovery

It is recommended that the use of absorbent "socks" and monitoring of trace amounts of free product in MW-8 be continued while the next phase of delineation is implemented. The need for future use of absorbent socks will be re-evaluated as part of the summary report prepared to present the findings of the tasks recommended in this report.

5.7 First Unit Coking Area

As noted in Section 4.7, there appear to be no shallow or deep groundwater impacts in this area. It is recommended that monitoring be continued according to U. S. Steel's existing schedule, but no further action is warranted at this time.

5.8 Steel Works Area

As noted in Section 4.8, there appear to be no groundwater impacts associated with this area. It is recommended that monitoring be continued according to U. S. Steel's existing schedule, but no further action is warranted at this time.

5.9 Peters Creek Coke Yard Area

5.9.1 Shallow Groundwater Plume Delineation

Impacted shallow groundwater has been identified to the southeast toward the Coke Storage Area in samples from Wells OW-1, MW-17, and MW-103A and to the southwest, west, and northwest toward Peters Creek in samples from MW-16, TW-70, TW-71, and OW-2 through OW-4. A review of historical aerial photography and mapping of the former Peters Creek Lagoon boundaries over time were compared to the existing areal extent of the Peters Creek Lagoon slurry walls. That comparison shows that the historical areal extent of the former Peters Creek Lagoon was greater than the current footprint as defined by the slurry wall. While efforts appear to have been made to consolidate the contents of the old boundaries of former Peters Creek Lagoon into the current footprint, it is possible that residual material may remain. Based on the findings of the GCWP implementation, it is recommended that additional delineation be completed.

Specifically, additional shallow groundwater monitoring wells or well points should be installed between Wells TW-71, OW-2, and OW-3 and Peters Creek to provide data on groundwater quality approaching Peters Creek. Given the steep terrain in that area, specific procedures for installing the monitoring well locations will need to be provided to PADEP after on-site meetings with drilling contractors and safety professionals.

In addition to the groundwater quality within the shallow groundwater zone approaching Peters Creek, it is recommended that three stream staff gauges be installed: one upstream of the former Peters Creek Lagoon (north-northwest of Well P-20), one mid-point of the former Peters Creek Lagoon (near TW-71), and one downstream of the former Peters Creek Lagoon, but upstream of the Peters Creek Seep Collection Trench and Clairton Waste Water Treatment Plant discharge.

The staff gauges will provide data to assist in the determination of gaining or losing stream conditions and to provide data to facilitate potential loading evaluation.

To delineate shallow groundwater impacts to the southeast of the former Peters Creek Lagoon, three nested well pairs (shallow and deep) should be installed between MW-17 and the former lagoon. The proposed shallow wells will provide information on the extent of impact noted at Well MW-103A.

The purpose of the three wells pairs southeast of the former Peters Creek Lagoon will also be to provide hydraulic data regarding potential interaction between the two groundwater-bearing zones and enable the evaluation of groundwater quality data within the deeper zone. Those three deeper wells will assist in the delineation of impacted groundwater found in samples collected from Well MW-103B.

5.9.2 Deep Groundwater Plume Delineation

The installation and sampling of the nested (shallow and deep) wells between OW-1 and MW-17 in the Coke Storage Area as recommended in Section 5.9.1 will provide delineation of the deep groundwater impacts identified in MW-103B and determine if those impacts extend to the southeast. Deep groundwater has been evaluated between the former Peters Creek Lagoon and Peters Creek and is not impacted.

5.9.3 Product Recovery

LNAPL transmissivity in the area was estimated at 0.007 ft^2/day, compared to a nominal minimum value of 0.015 ft^2/day for sustainable recoverability. Therefore, the use of skimmers or other automated systems in an effort to recover free product from the area is not recommended as a sustainable alternative. Instead, manual recovery (by bailer when thicknesses are greater than a sheen, and by absorbent "socks" otherwise) is recommended, to be completed after the gauging and sampling efforts each quarter while the next phase of delineation is implemented. The need for future use of absorbent socks will be re-evaluated as part of the summary report prepared to present the findings of the tasks recommended in this report.

5.9.4 Groundwater Recovery

In addition to free product recovery, it is recommended that the use of the Peters Creek Seep Collection Trench, sump, and treatment system be continued until no measurable free product in the area is detected for a period of eight consecutive quarters. Despite these measures, migration of impacted groundwater located outside of the lagoon slurry wall northwest and southeast into Peters Creek is a concern, as indicated in Section 4.9.

Benzene concentrations in groundwater samples collected from Monitoring Well TW-71, located approximately 80 feet from the bank of Peters Creek, are stable but above the SHS MSC.

In order to better evaluate potential surface water impacts in the Peters Creek Coke Yard Area, the following recommendations are made:

- It is recommended that stream staff gauges be installed in Peters Creek at accessible points, preferably at one upstream location (near P-20), one location corresponding to the greatest maximum potential stream loading (i.e., opposite Monitoring Well TW-71), and one downstream location nearer to the area entrance but upstream of the Peters Creek Seep Collection Trench and Clairton Waste Water Treatment Plant discharge as discussed in Section 5.9.1. Stream staff gauge monitoring conducted concurrently with the quarterly gauging of the site monitoring wells would provide a better understanding of groundwater/surface water interaction. In addition, the collection of surface water samples near the stream staff gauges is recommended.
- Following the installation, surveying, gauging, and receipt of a minimum of four quarters of surface water quality data of samples collected from the stream gauges, modeling is recommended to evaluate if potential loading is occurring. This would likely be done using SWLOAD (PADEP, 2002) or a similar model to calculate the direct loading, followed by the use of PENTOXSD (PADEP 2004) to model the surface water mixing, both under "standard" conditions and under drought conditions.
- Previous investigations completed at the Peters Creek Coke Yard indicated that several seeps exist along the bank of Peters Creek; several of these seeps contained an oily sheen and coal tar odors, and analyses indicated that these seeps contributed concentrations of benzene and phenol to Peters Creek. Sampling and an estimation of flow of those seeps is recommended for correlation purposes to shallow groundwater.

5.10 Motor Repair Shop Area

As noted in Section 4.10, there appear to be no groundwater impacts associated with this area. It is recommended that monitoring be continued according to U. S. Steel's existing schedule, but no further action is warranted at this time.

5.11 Crane Yard Area

As noted in Section 4.11, there appears to be no appreciable plume of impacted groundwater in this area, although a small thickness of free product has been detected in at least one of the wells. Recommendations, therefore, include product recovery using absorbent "socks" (as the measured product thickness is too small for the use of skimmers or similar technology) coupled with continued monitoring on an annual basis.

6.0 Summary

Recommendations were provided in the GCWP to address data gaps associated with the known groundwater impairment at the Clairton Works plant. Those recommendations were implemented in 2014 through 2015 in order to better understand and characterize the status of groundwater quality and recovery efforts ongoing at the Clairton Works plant and can be summarized as follows:

- The installation, development, and sampling of four monitoring wells in areas where no monitoring wells existed to provide horizontal and vertical delineation of impacted groundwater was completed. Three of those new wells were installed in the shallow groundwater zone, while one was installed in the deep groundwater zone (Section 3.1). Groundwater samples collected from those wells helped provide horizontal and vertical delineation in areas which would otherwise be unknown.

- Twelve shallow groundwater wells (inclusive of the three newly installed wells) were sampled for four consecutive quarters to better delineate dissolved-phase benzene and phenol groundwater impacts in in the Oil Seep Investigation Area, Keystone Area, Crane Yard Area, Motor Repair Shop Area, and Peters Creek Coke Yard (Section 3.2.1). Groundwater samples collected from those wells helped provide horizontal and vertical delineation of shallow groundwater impacts in those areas.

- Seven deep groundwater wells (inclusive of one newly installed well) were sampled for four consecutive quarters to better delineate dissolved-phase benzene and phenol groundwater impacts in in the Keystone Area, Coal Storage Area, BTX Plant Area, and the Tar Plant Area (Section 3.2.2). Groundwater samples collected from those wells helped provide horizontal and vertical delineation of deep groundwater impacts in those areas.

- Jersey barriers were placed around six wells throughout the Clairton plant to provide monitoring wellhead protection from vehicular traffic to ensure the existing monitoring well network is not jeopardized (Section 3.3.1).

- Two wells which appeared to be silted in during the well inventory and inspection activities conducted in 2013 were redeveloped resulting in the removal of several feet of silt from within the wells (Section 3.3.2).

- Well repairs were performed on several wells throughout the plant and included the placement of locking compression caps on wells which did not have caps and were exposed to the atmosphere, repairing the broken riser of one well, and providing a protective vault for a flush-mount well which was unprotected (Section 3.3.3).

- Well locks were placed on 67 wells. Forty-four wells were unable to be locked for a variety of reasons, and those which are able to be locked will be at a later date pending an alternative method for repairing locking lids (Section 3.3.4).

- Well location activities were conducted via geophysical means for wells which were not located during the well inventory and inspection in 2013. Eleven wells were located by geophysical means (Section 3.4.1).

- Thirteen unused or otherwise nonfunctional wells were plugged and abandoned. Nine wells remain to be abandoned and will be so at a later date pending the receipt of necessary excavation permits and rail lockout authorization (Section 3.4.2).

- LNAPL baildown testing was completed on two wells at the Clairton plant which exhibited quantifiable amounts of free product. The results of the testing indicate that free product recovery is not feasible (Section 3.5.1). Where smaller amounts of free product were identified, oil absorbent socks were placed into those wells (Section 3.5.2).

- An assessment of groundwater recovery efforts and requirements at the Clairton plant was completed. The groundwater recovery assessment focused on the BTX Trench and Peters Creek Seep Collection Trench (Sections 3.6.1 and 3.6.2).

- Mann-Kendall Statistical Analyses were completed for those wells exhibiting the highest benzene and/or impact for determination of groundwater recovery requirements (Section 3.6.3).

Based on the results of these activities, the status of the groundwater quality and the effectiveness of the existing approved monitoring, collection, recovery, and treatment systems at the Clairton Works plant can be summarized as follows:

- Groundwater beneath the facility exists in two vertically distinct zones, designated the shallow groundwater zone and deep groundwater zone for discussion purposes (Section 2.3).

- Groundwater in both the shallow and deep groundwater zones beneath the Coal Yard Area, Second Unit Coking Area, First Unit Coking Area, and Steel Works Area does not appear to be impacted by benzene or phenols at concentrations above their respective Act 2 SHS MSCs.

- Shallow groundwater benzene and phenol impacts appear to be found in five distinct plumes, located in the BTX Plant Area, the Tar Plant Area, the Oil Seep Investigation Area, the Keystone Area, and the Peters Creek Coke Yard Area (Table 2, and Figures 5A through 5C).

- Deep groundwater benzene and phenol impacts appear to be found in two distinct areas, located in the BTX Plant Area and Peters Creek Coke Yard Area (Table 3, and Figures 6A through 6C).

- Based on the results of groundwater sampling during implementation of the GCWP, data gaps exist within the horizontal and vertical delineation of shallow and deep groundwater in the BTX Plant Area, Keystone Area, and Peters Creek Coke Yard Area, requiring further investigation.

- Free product recovery is not feasible at the site in wells which exhibit measureable volumes of free product.

- The BTX Trench is fully capable of intercepting all incoming groundwater, plus additional water from other areas outside of the plume. However, its current operation in which extraction is increased when benzene concentrations in the trench are highest provides a lag time for recovery of impacted groundwater.

- The recovery well system in the Tar Plant Area is performing well and continues to produce a sharp cone of depression on the groundwater elevation (Figures 3A through 3C) and tight benzene isoconcentrations (Figures 5A through 5C).

- The recovery well system in the Oil Seep Investigation Area may not be performing at optimum conditions based on concentrations of benzene in samples from Well MW-99 located near the recovery wells.

- The Peters Creek Seep Collection Trench may not be sufficient enough to handle benzene-impacted shallow groundwater in this area.

- Decreasing concentration trends in benzene and phenols over time were noted in the results of groundwater samples collected from a number of monitoring wells. Conversely, increasing concentration trends in samples collected from many of the facility recovery wells suggest that impacted groundwater capture in those wells is occurring.

- Phenol was only identified in four shallow wells at the Clairton Plant at concentrations above its respective SHS MSC of 2 mg/L (MW-39, TW-55, RW-26, and OW-1). Groundwater samples collected from other wells in the areas immediately surrounding those wells indicate that phenol is currently not impacting the Monongahela River or Peters Creek site-wide.

Based on these findings, a series of recommendations are offered. A summary of these recommendations follows:

- Resumption of quarterly sampling of wells identified in Table 8 of the GCWP for continued delineation purposes for a period of 12 months.

- Collection of groundwater elevations in all site wells quarterly.

- Installation of three shallow groundwater monitoring wells in the BTX Plant Area and quarterly sampling for a duration of 12 months for delineation purposes and monitoring of BTX Trench operation (Section 5.2.).

- Installation of two deep groundwater monitoring wells in the BTX Plant Area, one on each side of the BTX Trench, and quarterly sampling for a duration of 12 months for delineation purposes.

- Sampling of Wells TW-73 and TW-90 in the BTX Plant Area quarterly for duration of 12 months to assist in the evaluation of deep groundwater conditions.

- Evaluate the potential need for recovery wells in the area of MW-39 by conducting a pumping test to define the location, yield, radius of influence, and feasibility of additional recovery wells to augment the existing BTX Trench system.

- Evaluate the performance of the Tar Plant Area recovery well system. Any inefficiency in performance could result in rehabilitation or pump replacement. As part of ongoing monitoring of the recovery system, the bailer stuck in RW-38 should be removed for the collection of groundwater samples and groundwater elevations.

- Continued use of oil absorbent socks in wells site-wide which exhibit measurable quantities of free product while the next phase of delineation is implemented. The need for future use of absorbent socks will be re-evaluated as part of the summary report prepared to present the findings of the tasks recommended in this report.

- Evaluate increased pumping or additional wells in the RW-94 pumping well cluster in the Oil Seep Investigation Area.

- Sampling of TW-57, TW-74, and TW-80 in the Keystone Area quarterly for a duration of 12 months for shallow groundwater delineation purposes.

- Sampling of TW-56, TW-60, and TW-81 in the Keystone Area quarterly for a duration of 12 months for deep groundwater delineation purposes.

- Installation of three shallow groundwater monitoring wells in the Peters Creek Coke Yard Area closer to Peters Creek and quarterly sampling for a duration of 12 months for delineation purposes toward Peters Creek.

- Installation of three nested sets of wells (shallow and deep) and quarterly sampling for a duration of 12 months for groundwater delineation purposes toward MW-17.

- Continued operation of the Peters Creek Seep Collection trench.

- Installation, surveying, and gauging of three stream staff gauges in Peters Creek and collection of in-stream surface water samples at those locations to be timed quarterly with groundwater sampling events for a duration of 12 months.

- Conduct SWLOAD (PADEP, 2002) and/or PENTOXSD (PADEP, 2004) modeling of surface water mixing after receipt of one year of staff gauge and surface water quality and groundwater quality results.

- Conduct an investigation and sampling of existing seeps along the eastern banks of Peters Creek in conjunction with in-stream surface water samples.

- After completion of the recommended additional delineation activities, evaluate the data and define remedial alternatives as needed and/or recommend further collection of data to delineate if other data gaps are identified. If further data gaps are identified following completion of the tasks identified in this document, a subsequent summary report will be prepared within 90 days from receipt of the final laboratory analytical data following the completion of four consecutive quarterly sampling events to be preceded by the completion of monitoring point/staff gauge installation. The summary report will describe the work completed, the findings of that work, and provide recommendations based on those findings that may include further delineation. However, if all data gaps have been adequately resolved, after implementation of the actions recommended in this summary report including the completion of four consecutive quarters of sampling following the installation of additional monitoring points and staff gauges, the Groundwater Site Characterization Report specified in Paragraph 6 of the 2013 COA will be prepared and submitted within 90 days after receipt of the final laboratory analytical data.

7.0 References

American Petroleum Institute (API), 2012. API Transmissivity Workbook. Microsoft Excel®-based calculation tool and associated User Guide dated January 2012.

ASTM International (ASTM), 1996. Standard Guide for Selection of Aquifer Test Method in Determining Hydraulic Properties by Well Techniques. Standard D 4043-96, updated in January 1999; 6 pp.

ASTM, 2013. Standard Guide for Estimation of LNAPL Transmissivity. Standard E2856-13, dated May 2013; 68 pp.

Baker Environmental, Inc., 2001. Peters Creek Lagoon Work Plan: Pilot Nitrate Test. Technical work plan dated July 2001.

Bouwer, H., 1989. The Bouwer and Rice slug test – an update. Ground Water, vol. 27, no. 3; pp. 304-309.

Bouwer, H. and R.C. Rice, 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resources Research, vol. 12, no. 3; pp. 423-428.

CB&I, 2013a. 120-Day Compliance Summary Report: United States Steel Corporation – Clairton Works. Technical report dated July 11, 2013.

CB&I, 2013b. Groundwater Characterization Work Plan (GCWP): United States Steel Corporation – Clairton Works. Technical report dated September 23, 2013.

Cooper, H.H., J.D. Bredehoeft, and S.S. Papadopulos, 1967. Response of a finite-diameter well to an instantaneous charge of water. Water Resources Research, vol. 3, no. 1; pp. 263-269.

Crouse & Company, 2013. Design Engineer's Report: Wastewater Treatment Plant Groundwater Remediation (Former Peter's Creek Lagoon Area). Technical report dated February 2013.

Duffield, G.M., 2007. AQTESOLV® for Windows, Version 4.5 (analytical software package). HydroSOLVE, Inc., Reston, VA.

Foster Wheeler Environmental Corporation, 2002. United States Environmental Agency, Region III Corrective Action Program: Final Environmental Indicator Inspection Report for U. S. Steel (Clairton Plant). Technical summary report dated December 2002.

Geraghty & Miller, Inc., 1996. Remedial Action Plan: Peters Creek Lagoon, Clairton, Pennsylvania. Technical report dated September 5, 1996.

Interstate Technology & Regulatory Council (ITRC), 2009. Evaluating LNAPL Remedial Technologies for Achieving Project Goals. LNAPL-2; Washington, DC: ITRC's LNAPL team; 157 pp.

Keystone Environmental Resources, Inc. (KER), 1990a. Assessment of the Peters Creek Coke Yard Well Recovery System. Technical report dated May 1990 (revised August 1990).

KER, 1990b. An Evaluation of In Situ Bioremediation: Peters Creek Coke Yard, Clairton, PA. Technical report dated May 1990.

KER, 1991a. Well 10 Area Study Phase II Report. Technical report date January 1991.

KER, 1991b. Well 7 Area Study Phase II Report. Technical report date January 1991.

Pennsylvania Department of Environmental Quality (PADEP), 2001. Groundwater Monitoring Guidance Manual. Technical guidance document 383-3000-001, dated December 1, 2001.

PADEP, 2002. SWLOAD5B, Method for Estimating Stream Loading from Groundwater. Microsoft Excel®-based calculation tool dated February 8, 2002.

PADEP, 2004. Technical Reference Guide (TRG) PENTOXSD for Windows PA Single Discharge Wasteload Allocation Program for Toxics, Version 2.0. Bureau of Water Supply and Wastewater Management technical guidance document 391-2000-011, dated May 22, 2004.

PADEP, 2007. FATBACK4 "Reverse Mode" Spreadsheet: Back Calculation to Source – Advective Transport with Three-Dimensional Dispersion and Retardation. Microsoft Excel®-based calculation tool dated August 22, 2007 and associated Help Document dated December 27, 2007.

PADEP, 2013. Consent Order and Agreement in the Matter of The United States Steel Corporation and Koppers, Inc. Clear Steams Violations. Legal document dated March 15, 2013.

United States Environmental Protection Agency (USEPA), 2006. Data Quality Assessment: Statistical Methods for Practitioners (EPA QA/G-9S). Technical guidance document EPA/240/B-06/003, dated January 2006.

United States Steel Corporation (U. S. Steel), 2014. Consent Order and Agreement: Clairton Works Benzene Study and Third Amendment to Consent Order, Peters Creek Lagoon Investigation, 3rd Quarter 2014 Progress Report. Technical report submitted October 21, 2014 to PADEP.

Weavertown Environmental Group (WEG), 1996. Phase I and II Slurry Wall Investigation: U. S. Steel Clairton Works, Clairton, Pennsylvania. Technical report dated February 9, 1996.

Weston Geophysical Corporation, 1990. Phase I Geophysical Investigation: Peters Creek Lagoon. Technical report dated August 1990.

Wisconsin Department of Natural Resources (WDNR), 2001. Remediation and Redevelopment Form 4400-215 ("Mann-Kendall Statistical Test"), Microsoft Excel®-based calculation tool dated February 2001.

Yeskis, D. and B. Zavala, 2002. Ground-water sampling guidelines for Superfund and RCRA project managers. USEPA Office of Solid Waste and Emergency Response Ground Water Forum Issue Paper (technical guidance document) EPA 542-S-02-001, dated May 2002.